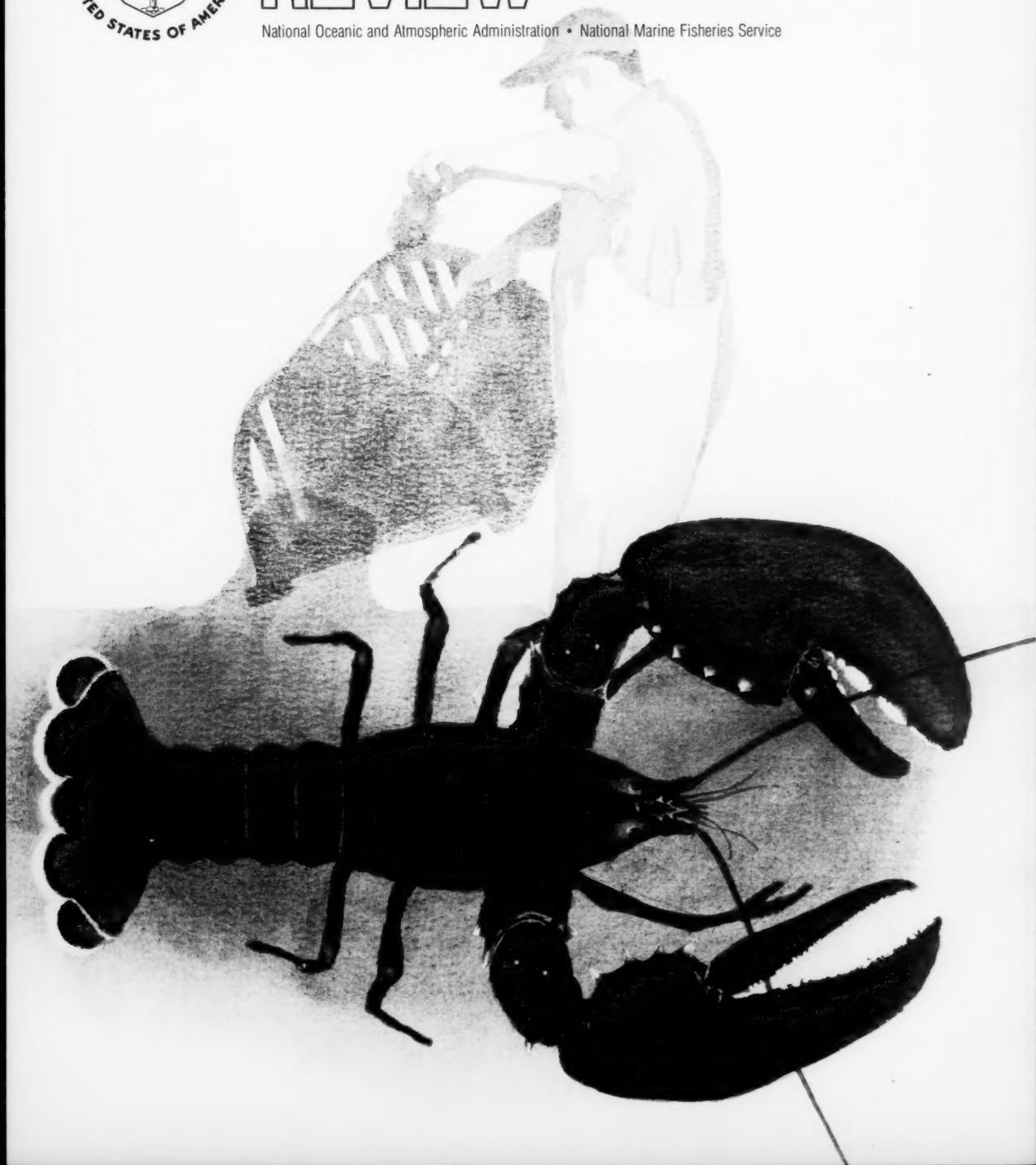


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CONTENTS

Articles

- 2 Trap Design and Ghost Fishing: An Overview
Ronald Joel Smolowitz
- 9 Ghost Fishing of Vented and Unvented Lobster, *Homarus americanus*, Traps
K. J. Pecci, R. A. Cooper, C. D. Newell, R. A. Clifford, and R. J. Smolowitz
- 44 A Preliminary Study of Timed Release Mechanisms for Lobster Traps
Alan J. Blott
- 50 The Effects of Different Escape Vents on the Selectivity of Lobster Traps
Vernon E. Nulke
- 59 Trap Design and Ghost Fishing: Discussion
Ronald Joel Smolowitz
- 68 Annotated Bibliography on Lobster Trapping and Related Subjects
Ronald Joel Smolowitz

Department

- 78 NOAA/NMFS Developments

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Lobster, *Homarus americanus*, Trap Design and Ghost Fishing

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INTRODUCTION

The Northeast Fisheries Center of the National Marine Fisheries Service has conducted research on the American lobster, *Homarus americanus*, for many years. Recently, research efforts have been directed toward forming a data base upon which recommendations for management of the inshore and offshore stocks in waters off the New England and Mid-Atlantic coasts can be based. The Center is assembling information on population, size, stock separation and mixing, growth rates, mortality rates, and recruitment indices.

To understand the effects of fishing on the resource, fisheries managers need not only catch/effort statistics and total weight and size composition of removals, but also data on the effects of non-selective and destructive fishing methods. Fisheries engineers and diver/biologists of the Center conducted a series of studies into these latter two factors; the results of this research are contained herein.

Trap Design and Ghost Fishing: An Overview

RONALD JOEL SMOLOWITZ

INTRODUCTION

This paper presents necessary background information for the subsequent papers on lobster trap design and ghost fishing in this issue of *Marine Fisheries Review*. A brief review of the lobster fishery and management is followed by a discussion of ghost fishing and escape vents.

RANGE

The American lobster, *Homarus americanus*, is found naturally on the east coast of North America, from North Carolina to Labrador, and is most abundant from Nova Scotia to New York. While most lobster fishing occurs in inshore waters, defined in this paper as all coastal waters extending 30 nautical miles seaward, since the early 1950's the offshore lobster stocks (along the edge of the continental shelf) have been increasingly fished.

THE FISHERY

Lobsters in the inshore fishery are caught mostly in traps or pots (the two terms are used interchangeably) as described by Everett (1972). Offshore lobsters have been harvested using otter trawl nets that are specifically rigged for lobster fishing or that catch lobsters incidentally to fishing groundfish. In 1968 an offshore pot fishery developed using a larger version of the inshore pot (Doliber, 1973:63).

The lobster fishery is the most valuable fishery on the east coast of the United States. In 1969 lobster landings were a record 33.8 million pounds—worth \$29 million (Table 1). In New

England this represented a 2 percent increase in volume and a 13 percent increase in value over the 1968 landings. A 2 percent decline in catch by inshore pot lobstermen was more than offset by a 29 percent increase in catch by offshore otter trawlers. New York

and New Jersey's share of the harvest increased by 20 percent in volume and 24 percent in value over 1968 levels. These increases were due to a more intensive inshore pot fishery which resulted when fishermen diverted their effort from black sea bass, *Centropristis striata*, to lobsters (National Marine Fisheries Service, 1969).

By 1972 the lobster landings were down to 32.3 million pounds, but the value of the catch was in excess of \$39 million (Table 2). The inshore pot fishery landed 23 million pounds—a significant drop from the 27 million pounds caught inshore in 1969. However, the offshore landings had increased by nearly 2 million pounds due to increased effort in the offshore pot

Table 1.—Lobster fishery statistics for 1969 and 1970.

	TOTAL LANDINGS			POT FISHING					OTTER TRAWL -Lobster				(Pounds) incidental to Landings	REMARKS	
	1,000 lbs	1,000 \$	Fishermen	Vessels	Boats	Traps	Landings (1,000 lbs)	Fishermen	Vessels	Landings (1,000 lbs)					
1969	ME	19,835	16,047	5,814	35	5,669	819,375	19,835						35 vessels - 402 gross tons total	
	N.H.	732	652	261		193	17,160	732							
	MA	4,965	4,741	1,217	7	1,021	132,303	3,455	152	24	1,249	220,500		7 pot vessels - 1,010 gross tons total	
	R.I.	4,246	3,787	228	3	185	22,480	892	198	41	3,323	31,200			
	CT	933	945	445	9	364	20,704	804	12	3	126	2,700			
	TOTAL (N.E.)	30,711	26,172	7,965	54	7,432	1,012,022	25,718	362	68	4,698	254,400			
	N.Y.	1,416	1,415	261	17	193	37,195	883	72	18	461	69,100			
	N.J.	1,434	1,212	53	8	24	12,590	974	198	47	329	125,800			
	DE														
	TOTAL (N.E.)	2,850	2,627	314	25	217	49,785	1,857	270	65	790	194,900			
	MD	26	21									21,700		4,800 lbs caught in fish traps	
	VA	181	123						37	7	181				
TOTAL CHESA	207	144						37	7	181	21,700				
TOTAL	33,768	28,984	8,279	79	7,649	1,061,077	27,575	669	140	5,669	471,000				
1970	ME	18,172	17,202	6,326	35	6,289	1,180,000	18,172							
	N.H.	688	722	323		237	17,800	688							
	MA	5,685	5,853	1,334	7	1,092	138,646	4,206	102	16	1,039	397,200			
	R.I.	5,195	5,212	307	5	211	30,257	1,620	185	38	3,561	12,800		5 pot vessels - 396 gross tons total	
	CT	673	715	670	9	535	25,719	671				1,800		9 pot vessels - 87 gross tons total	
	TOTAL (N.E.)	30,413	29,704	8,960	56	8,364	1,392,422	25,357	287	54	4,600	411,800			
	N.Y.	1,647	1,847	375	25	266	47,070	943	78	21	647	55,900		25 pot vessels - 409 gross tons total	
	N.J.	1,836	1,739	63	17	28	15,450	706	211	52	1,035	50,500		17 pot vessels - 171 gross tons total, 43,800 lbs caught in fish traps	
	DE														
	TOTAL (N.E.)	1,483	3,586	438	42	294	62,520	1,649	289	73	1,682	106,400			
	MD	22	20						10	2	13	500		7,500 lbs caught in fish traps	
	VA	229	149						47	9	98	130,600			
	TOTAL CHESA	251	169						57	11	111	131,100			
	TOTAL	34,147	33,459	9,398	98	8,658	1,454,942	27,006	633	138	5,393	649,300			

Vessel - over 5 tons

Boat - under 5 tons

Small catches by dredges, gill nets, by hand, dip nets, and diving not included

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fishery. The 1972 offshore pot landings were 6.3 million pounds compared with 115,000 pounds in 1969. Otter-trawl catch declined from 6.8 million pounds in 1969 to 2.4 million pounds in 1972.

The average annual landings between 1971 and 1975 were 30.4 million pounds. In 1976, lobster landings were 31.7 million pounds, worth a record \$52.7 million (Robinson, 1977).

Tables 1-3 present an overall review of the lobster fishery, by state, from 1969 to 1974. The data were extracted from *Fishery Statistics of the United States* for the corresponding years, except for 1974 which is unpublished preliminary data.

MANAGEMENT

Because of the rapid decline of the inshore lobster catch and the increasing exploitation of the offshore stocks, methods to manage the resource are being discussed. Such discussions are not new. For over a century, concern for the protection of the American lobster has been shown by both industry and government. Calls for the protection of lobsters are usually stimulated by fear of overfishing to the point of commercial extinction.

Fishermen and researchers alike have considered government regulation of lobster fishing one way to protect the lobster resource since the earliest years of the fishery (Herrick, 1911; Field, 1911). One of the first restrictive pieces of legislation on lobster fishing was enacted in Sweden in 1686. The first protective legislation for lobsters in this country was formulated in Provincetown in 1812. The Provincetown law required permits for lobster fishing and was actually more concerned with the predator, man, than with the prey. By 1874, overfishing, due to the rapidly rising demand of the canning industry, caused Massachusetts to make it illegal to sell any lobster less than 10.5 inches in overall length. Maine's first lobster laws, like those of Massachusetts, were concerned with residency requirements. In the 1870's, coincidentally with Massachusetts, laws were enacted that restricted canning, but it was not until 1895 that the 10.5-inch lobster regulation terminated canning in Maine entirely.

Since then government regulation has taken many forms. There are laws governing minimum and maximum sizes. Fishing seasons are regulated. There are also many regulations regarding the marketing of lobsters. Egg-bearing females are protected. Even limited entry has been used to restrict the number of Canadian canneries in the last century (Collins, 1904:22).

Other forms of regulations have dealt mainly with the gear used. Many states require that pots and buoys have means of identification as an aid for law enforcement. Some types of gear are banned outright, such as scuba gear in Maine. Otter trawlers are not allowed to operate in certain areas.

Most of these regulations have been

attempts to deal with the obvious situations that may cause resource depletion. However, there are some less obvious problems. One of these is "ghost fishing."

GHOST FISHING

Ghost fishing is defined as the ability of fishing gear to continue fishing after all control of that gear is lost by the fisherman. This problem was first recognized in gillnet fisheries and was a major topic of discussion at a Food and Agriculture Organization (FAO) meeting in Rome in 1960.

The chief of the Fishing Gear Section of FAO's Fisheries Division stated that bottom-set cod gill nets that were recovered months or years after being lost

Table 2.—Lobster fishery statistics for 1971 and 1972.

	STATE	TOTAL LANDINGS		POT FISHING				OTTER TRAWL—Lobster				(Pounds) Incidental D.T. Landings	REMARKS
		1,000 lbs	1,000 \$	Fisher- men	Vessels Boats	Traps	Landings (1,000 lbs)	Fisher- men	Vessels	Landings (1,000 lbs)			
1971	ME	17,588	17,481	6,670	34 6,635	1,278,226	17,558						34 vessels - 394 gross tons
	N.H.	667	741	345	240	18,600	667						
	MA	6,146	6,894	1,099	10 873	110,672	4,816	60	10	408	890,600		
	R.I.	5,309	6,030	319	22 202	40,701	2,930	200	41	2,458			22 pot vessels - 8,817 gross tons
	CT	523	657	609	7 427	25,929	521				1,000		
	TOTAL (N.E.)	30,113	31,811	9,042	73 8,377	1,474,128	26,492	260	51	2,866	891,600		
	NY	1,790	2,054	474	35 309	55,325	1,039	79	21	727	23,100		
	NJ	1,323	1,460	123	30 36	31,640	479	179	47	769	35,400		
	DE	30	41	21	9	475	30						
	TOTAL (N.E.)	3,143	3,555	618	65 354	87,440	1,548	258	68	1,496	58,500		
1972	ME	28	28								23,500		4,600 lbs caught in fish traps
	VA	234	200	19	3	3,200	111				122,300		
	TOTAL CHESA	262	228	19	3	3,200	111				145,800		
	TOTAL	33,718	35,594	9,679	141 8,731	1,564,768	28,151	518	119	4,362	1,095,900		
	ME	16,257	18,588	7,039	30 6,974	1,448,365	16,256						
	N.H.	674	809	277	225	15,958	673						
	MA	8,032	10,276	1,204	11 931	145,127	7,077	60	10	410	511,700		4,138 offshore traps caught 2.8 million lbs
	R.I.	3,361	4,319	418	37 241	47,367	2,475	104	22	872	13,400		14,675 offshore traps caught 1.6 million lbs
	CT	540	777	758	2 512	33,761	539				400		
	TOTAL (N.E.)	28,864	34,769	9,696	80 8,683	1,690,578	27,020	164	32	1,282	525,500		
1972	NY	1,145	1,825	506	33 353	53,150	1,011	62	17	121	11,400		
	NJ	1,308	1,828	171	53 31	42,010	838	120	32	447	15,100		
	DE	22	36	19	8	615	22						
	TOTAL (N.E.)	2,475	3,689	696	86 392	95,775	1,871	182	49	568	26,500		
	MD	21	26	4	1 1	500	15						5,400 lbs caught in fish traps
	VA	884	1,028	33	5	6,000	877				6,100		
	TOTAL CHESA	905	1,054	37	6 1	6,500	892				6,100		
	TOTAL	32,244	39,512	10,429	172 9,276	1,792,853	29,783	346	81	1,850	558,100		

Vessel - over 5 tons

Boats - under 5 tons

Small catches by dredges, gill nets, by hand, dip nets, and diving not included.

contained numerous fish skeletons and live fish. He referred specifically to an intensive fishery around Iceland that employed synthetic fiber nets fitted with plastic and metal floats—fishing gear that could continue to fish without rotting for long periods (U.S. Department of Interior, 1968).

The solution devised to counter the problem was to hang the nets from the floats with natural fiber twine. If the nets were lost, this twine would rot causing the nets to separate from the floats and sink; thus the gear would no longer be an effective fishing unit (Von Brandt, 1964:168).

The threat of ghost fishing in a pot fishery became a concern in the west

coast king crab, *Paralithodes camtschatica*, fishery in the early 1960's. When this fishery began in the 1950's, the first pots were large versions of those used for Dungeness crabs, *Cancer magister*. These pots were covered by natural fiber twines which usually rotted out in less than a season (Rietze, pers. commun.¹). During the 1960's, pot design evolved; king crab pots are now constructed with steel frames covered with synthetic fiber web, making them highly durable. This durability made it more urgent to

¹Harry L. Rietze, Director, Alaska Region, National Marine Fisheries Service, NOAA, P.O. Box 1668, Juneau, AK 99802.

answer the question of whether or not lost pots continued to fish and for how long, especially when gear-loss rates were estimated at over 3,000 pots annually (Meyer, pers. commun.²).

The National Marine Fisheries Service (NMFS) began in 1970 to study the problem of lost king crab pots to determine if they did continue to fish and if trapped crabs could escape. In addition, information was gathered on deterioration rates of different pot web hanging materials (Meyer, footnote 2). The preliminary results of the experiment indicated that king crabs could escape from lost pots. However, the same study reported that lost pots that were recovered often contained as many as 100 live marketable king crabs.

Some observations that gave impetus to the above research were made by McNeely (NMFS, pers. commun.³) on a cruise aboard the *John N. Cobb* in January 1970. On this cruise nine experimental sablefish (blackcod), *Anoplopoma fimbria*, pots were recovered which had been lost for 1 month. Six of the pots contained snow crabs (*Chionoecetes*), as many as 32 per pot, and the average catch of sablefish was 12 fish per pot. There were also numerous remains of sablefish in the pots.

Hipkins and Beardsley⁴, in a progress report on the development of sablefish pots, felt that ghost fishing of these pots might be a serious problem: "It appears then that blackcod (sablefish) pots (and probably most other pot gear) will continue to fish with dead fish serving as bait to attract new fish which eventually die to attract more fish and so ad infinitum until the pot deteriorates to the point where fish can escape. This process of deterioration is slow and

Table 3.—Lobster fishery statistics for 1973 and 1974.

STATE	TOTAL LANDINGS		POT FISHING				OTTER TRAIL—Lobster				(Pounds) Incidental C.T. Landings	REMARKS	
	1,000 lbs	1,000 \$	Fisher- men	Vessels	Boats	Traps	Landings- (1,000 lbs)	Fisher- men	Vessels	Landings- (1,000 lbs)			
1973	ME	17,044	23,270	8,151	32	7,863	1,822,490	17,044					
	N.H.	497	680	468		363	22,299	497					
	MA	5,624	8,527	1,093	10	957	159,773	5,120	62	10	260	219,400	6,150 offshore traps caught 1.7 million lbs
	R.I.	2,773	4,235	402	36	228	52,204	2,427	74	15	459		20,375 offshore traps caught 1.7 million lbs
	CT	544	841	514	3	317	27,523	543					
	TOTAL (N.E.)	26,482	37,553	10,628	81	9,728	2,084,289	25,831	136	25	719	219,400	
	NY	892	1,428	494	31	365	52,450	798	56	16	93	800	3,400 offshore traps caught 0.4 million lbs
	NJ	1,353	2,234	175	48	35	40,555	926	73	22	420	7,900	12,965 offshore traps caught 0.4 million lbs
	DE	29	51	41	1	13	764	29					400 offshore traps caught 1,500 lbs
	TOTAL (N.E.)	2,284	3,713	710	80	413	93,779	1,753	129	38	513	8,700	
1974	MD	24	33	5	1		800	20					3,700 lbs caught in fish traps
	VA	199	285	36	6		6,400	182	5	1	7	10,200	
	TOTAL (S.E.)	223	318	39	7		7,200	202	5	1	7	10,200	
	TOTAL	28,989	41,584	11,377	168	10,141	2,185,268	27,786	270	64	1,239	238,300	
	ME	16,457	23,212	10,628		7,589	1,789,900	16,457					
	N.H.	498	702	402		276	23,105	498					
	MA	5,943	9,103	1,471	42	1,062	170,100	4,993	60	11	950		24,100 offshore traps caught 1.1 million lbs
	R.I.	3,129	5,201	544	41	230	56,500	2,650	82	16	579		23,500 offshore traps caught 1.8 million lbs
	CT	647	1,095	715		515	23,925	647					
	TOTAL (N.E.)	26,674	39,313	13,760	83	9,672	2,063,530	25,245	142	27	1,529		
1974	NY	730	1,395	554	9	376	56,200	661	49	14	69		5,800 offshore traps caught 0.3 million lbs
	NJ	1,191	1,915	107	14	55	32,700	716	90	18	475		9,700 offshore traps caught 0.3 million lbs
	DE	25	45	43	2	13	1,500	25					
	TOTAL (N.E.)	1,946	3,355	704	25	444	90,400	1,402	139	32	544		
	MD	36	65	9	2	0	2,000	36					all caught offshore
	VA	274	504	20	5	0	3,000	274					all caught offshore
	TOTAL (S.E.)	310	569	29	7	0	5,000	310					
	TOTAL	28,930	43,237	14,493	115	10,116	2,158,930	26,957	281	59	2,073		

Vessel - over 5 tons

Boat - under 5 tons

Small catches by dredges, gill nets, by hand, dip nets, and diving not included.

²Robert Meyer, National Marine Fisheries Service, NOAA, P.O. Box 1638, Kodiak, AK 99615.

³Richard McNeely, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, 2725 Montlake Boulevard East, Seattle, WA 98112.

⁴Hipkins, F. W., and A. J. Beardsley, 1970. Development of a pot system for harvesting blackcod (*Anoplopoma fimbria*). A progress report. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Seattle, 31 p. Available at the Northwest & Alaska Fisheries Center, NMFS, NOAA, 2725 Montlake Boulevard East, Seattle, WA 98112.

could take years depending upon the materials employed in constructing the pot. The consequence of large numbers of ghost pots fishing in an unregulated manner in competition with fishermen could be catastrophic to the blackcod fishery. The lost pots will continue to fish long after the fishery is uneconomic for the commercial fishermen."

They recommended, as a solution, that a cotton web destruct panel be built into each pot. Subsequently the State of Washington issued a regulation on bottom-fish pots that requires: "A section of one vertical wall must be constructed of cotton fiber or one of the walls of synthetic fiber must be attached to the frame with cotton hangings to permit escapement of fish if the bottom-fish pot is lost (Wash. Dep. Fish. Regs., WAC 220-16-145, 1971).

Canadian fisheries managers, even without experimental evidence, thought it prudent to take action to prevent ghost fishing. Proposed regulations for the developing snow crab, *Chionoecetes opilio*, fishery contained provision that would have required all pots to be fitted with a 12-inch long section of netting laced with degradable material (Cormier, pers. commun.⁵).

Regulations of the State of Florida require that all spiny lobster, *Panulirus argus*, pots be constructed of wood so the pot, when lost, will eventually break and not continue to fish. Sixteen-gauge, 1-inch poultry-wire reinforcement is allowed on the pot side but not on the top or bottom. This reinforcement protects the pot from the "ravages of turtles." Escapable pots, e.g., ice cans and drums, are also permitted in the fishery (Seaman and Aska, 1974:58).

Though preventive regulations exist, the controversy on ghost fishing is far from settled. At a pot fishing and artificial baits symposium held at the University of Washington in March 1972, there was much debate on whether pots can fish unbaited. One king crab fisherman felt that lost unbaited pots do not continue to fish. He thought that a greater problem was lost gill nets

(tangle nets) which he has found at times to contain the remains of many king crabs (Jaeger, 1972).

At the same symposium it was stated that Dungeness crab fishermen in the Humboldt Bay, Calif., area were concerned with ghost fishing. Here, too, there was "... no sound experimental data as to the catch rate in such ghost pots" (Jaeger, pers. commun.⁶).

An analogous situation existed in Australia in a snapper (*Chrysophrys unicolor*) fishery. Local fishermen were afraid of the deleterious effect pots might have on the fishery and research was undertaken to identify problems. Continued fishing by lost pots was considered a possible problem, but here again no information was available on the many factors related to ghost fishing (Bowen, 1964). (This pot fishery was eventually banned in 1966, mainly due to the fact that the pots scraped along the sea bottom, when hauled, killing large areas of coral.)

In one of the most thorough research projects on pot fishing accomplished to date, factors affecting the performance of the "Antillean" fish trap (Munro et al., 1971) were studied. Many observations were made on catch rates, escapement, and mortality of a variety of species of reef fishes. The researchers found that although up to 50 percent of the entrapped fish eventually escaped, many others died due to physical deterioration, starvation, and predation. This last factor, predation of entrapped animals, has also been reported in the New Zealand rock lobster, *Jasus edwardsii* and *J. verreauxi*, fishery, the predator in this case being *Octopus maorum* (Ritchie, 1972).

The threat of ghost fishing in the New England lobster fishery became a point of concern during the development of the offshore pot fishery. The cruise report of the MV *Delaware* (Cruise 68-05, July 1968) documents the recovery of lost pots:

"Nineteen pots were recovered in May 26. These pots had been lost on March 17 when all the buoy lines

had parted at faulty swaged splices in the wires. The pots had been set in 175- to 210-fathom depths. One of the recovered pots was damaged by the grapnel—an entire side panel was missing. The remaining 18 pots contained a total of 24 lobsters which weighed 156.5 pounds—this is a catch rate of about 8.7 pounds per pot. All of the lobsters were quite large and they undoubtedly would have exceeded the 6.5-pound average weight if it had been possible to weigh them when they were first caught instead of after the extended period of starvation through which they had passed. The volume of meat within the lobster shells was exceedingly small for the size of each shell; one very large lobster had thrown both claws—the blackened remnant of the crushing claw was still in the pot with the lobster."

Experiences such as this, by both researchers and commercial fishermen, became more common as the fishery developed.

In November of 1971, McRae prepared material for an International Commission for the Northwest Atlantic Fisheries (ICNAF) advisory committee meeting that recommended action be taken to prevent the possibility of a ghost-fishing problem in the offshore lobster fishery (McRae, NMFS, pers. commun.⁷). In March of 1972, the Northeast Fisheries Center undertook the task of developing methods to prevent ghost fishing. Concurrently with NMFS research, Sheldon and Dow (1975) conducted a ghost trap experiment in Maine. They concluded that unbuoyed traps continued to fish, and that cannibalism resulted in the deaths of at least 15 percent of the lobsters entering the traps.

Factors Affecting Ghost Fishing

Initial research by the Center, consisting mostly of a literature review, concerned itself with identifying the factors affecting ghost fishing in the

⁵Fisheries and Environment Canada, Ottawa, Ontario, Canada K1A 0E6.

⁶Sig Jaeger, North Pacific Fishing Vessel Owner's Association, Fishermen's Terminal, Seattle, Wash.

⁷Ernest McRae, Southeast Fisheries Center, National Marine Fisheries Service, NOAA, 75 Virginia Beach Drive, Miami, FL 33149.



Figure 1.—A photo taken from a submersible at 100 m in Veatch Canyon of a lost trap that was no longer an effective fishing unit. A red hake surveys the scene.

offshore lobster fishery. These parameters were grouped as follows.

Number of pots lost.

By definition, the first criterion that a pot must meet to be considered a ghost pot is that it is lost. A lost pot is not a ghost pot unless it continues to fish after all control is lost. Pot loss in the offshore lobster fishery is caused by vessels inadvertently severing trawl strings, trawl strings become fouled, storms, and gear mechanical failure.

Pot type

The ghost-fishing catch rate is a direct function of how long the pot remains physically intact as an effective fishing unit (Fig. 1). While the offshore lobster fishery had a high pot-loss rate, it used the cheaper, less durable, wood-framed pot. As the loss rate decreases, fishermen tend to switch to highly durable pots.

The size of a pot is also important in assessing ghost fishing. Larger pots usually have higher catch rates.

Other key parameters affecting catch are pot selectivity (size range and species) and the effectiveness of the pot design in preventing escapement. The mortality caused by ghost fishing is di-

rectly related to the retention capability of the pot and the pot's selectivity.

Location where lost

The forces acting to destroy a pot as an effective fishing unit vary geographically and with depth. Corrosion rates are a function of interrelated variables such as temperature, depth, oxygen, salinity, and velocity. Biological deterioration varies at different locations and with temperature, velocity, and substrate. A pot can also be destroyed by storm surge or by being buried in the substrate.

The ghost-fishing catch rate varies with the target-species availability at different locations. Ghost-fishing mortality is probably related to the availability of predators and to hydrographic conditions; these two factors are also location dependent.

Target-species behavior

A ghost-pot's catch rate depends on why the target species enters the pot, e.g., bait and/or shelter-seeking behavior. It follows that the pot's retention rate is a function of this behavior as well as of pot design; some pots are designed to be inescapable, while others are hauled before the target species wants to leave.

Ghost-fishing mortality depends on

the target species' endurance of the adverse conditions of the pot. There can be self- or conspecific-inflicted injuries caused by behavioral response to the conditions of crowding, starvation, and environmental change.

Preventing and Decreasing Ghost Fishing

Two of the controllable factors affecting ghost fishing are rate of pot loss and pot type.

In the offshore lobster fishery, fishermen have placed much effort into decreasing their pot losses. These fishermen set trawl strings with up to 90 attached pots, sometimes extending over 1.5 km in length, on the ocean bottom. Foreign and domestic trawl fishermen, dragging midwater or bottom trawl nets, often work the same areas as the fixed-gear lobstermen. They sometimes inadvertently tow across the lobster-trawl strings and frequently sever the connections to surface buoys.

A partial solution to this problem has been to concentrate the pots in "pot fields" and report their positions to the Coast Guard. This solution has been further refined by dividing offshore waters into dragging and fixed-gear areas. The concentration of pot fields has led to lobster-trawl strings becoming fouled with each other and being lost. This problem has been reduced by the lobstermen setting their strings parallel to the bottom depth contours.

The above practices by the fishermen, along with experience gained in this new offshore lobster fishery, have decreased the annual pot-loss rate from as high as 100 percent to about 25 percent. This latter figure is comparable to the loss rate in the inshore lobster fishery.

The fishermen's immediate concern for decreasing gear loss is based on the direct economic costs and not a fear of a ghost-fishing problem. Their choice of pots is also based on direct economic costs, the primary variables being durability, handling, and catch rates. It can be assumed that a fisherman will use the most economically efficient pot available. The problem is to design this pot to prevent or reduce ghost fishing if the pot is lost, without introducing in-

efficiencies into the fisherman's operation. One approach would be to design the pot to selectively retain only legal-sized lobsters. Much research has been accomplished in this area in regard to protecting short lobsters.

Enforcement of size limits has always been a problem (Collins, 1904; Herrick, 1911; Field, 1911). Even today, by conservative estimates, the landed number of short lobsters exceeds 10 percent of legal landings. Though this illegality is difficult to document, it is not necessarily difficult to solve. Solutions available include: 1) increased enforcement pressure, 2) better education of the fishermen on the values of size limits, and 3) sublegal escape vents.

Escape Vents

Pots that contain escape vents could conceivably decrease ghost fishing related injuries and mortality. The word vent is defined here as an opening in a lobster pot, such as the space between the laths. An escape vent is an opening designed into the pot to allow lobsters to escape. The head ring in a pot is the entrance vent, though lobsters may also escape through it.

Sublegal escape vents allow lobsters under the legal minimum size to escape. A legal minimum size requirement is considered an effective biological and economic tool (Wilder, 1954; Thomas, 1973). While there is no consensus of what the optimum minimum size should be, few challenge the fact that size limits are necessary for protection of the lobster stocks.

Sublegal escape vents on lobster pots are not a new idea. The effects of lath spacing on the size composition of the catch has been recognized by fishermen ever since they began building pots.

Some of the earliest recorded scientific experiments on lath spacing were conducted by Adolph Neilsen, Superintendent of Fisheries in Newfoundland, in the 1890's (Templeman, 1958). He established the concept of using lath spacing as a means of regulating the catch of sublegal lobsters.

Newfoundland eventually enacted a law requiring 1 3/4-inch spacing in pots, but many fishermen were critical of the value of this law. They thought it did

not affect the catch of sublegals, that the bait was used up faster, and that legals could escape. In 1938 Templeman conducted experiments demonstrating that pots with the 1 3/4-inch spacing not only caught 80 percent fewer shorts (9-inch overall length), but were also able to catch more legal-sized lobsters than pots of smaller lath spacing (Templeman, 1939).

Wilder conducted similar experiments between 1943 and 1946 (Wilder, 1943, 1945, 1949). In areas where the legal size of the lobster was 7 inches overall, Wilder found that pots with 1 1/4-inch lath spacing decreased the catch of sublegals by 60 percent and increased the catch of legals when compared with pots of 1-inch spacing. Where the legal size was 3 1/2 inches on the carapace, 1 3/4-inch lath spaces allowed 75 percent of the shorts to escape without reducing the legal catch. Wilder states that pots with sublegal vents allowed the greatest increase in legal catch where the average size of lobsters caught was large. Where the average size was small, the greatest reduction in captured shorts occurred. In addition, wider-lath pots retained fewer crabs.

Experiments in Western Australia and Tasmania, testing the effectiveness of sublegal escape gaps (vents) on rock-lobster pots, provide results similar to that of the Canadians. Again, pots with escape vents decreased the amount of undersized lobsters caught and increased the catch of legal-sized lobsters (Winstanley, 1970, 1973; Bowen, 1963).

The crab fishermen of California, Oregon, Washington, and Alaska have a self-imposed regulation requiring escape vents in pots (Hipkins, 1972). These vents allow the smaller female crabs to escape. In California, a regulation regarding crab-pot escape-vent size became law effective January 1975.

In August of 1975 the State-Federal Lobster Management Program made up of representatives from New England and the Mid-Atlantic states, recommended that sublegal escape vents be required in all lobster traps. The recommendations, based in part on unpublished data from this study, and from Krouse and Thomas (1975), were

subsequently promulgated as regulations by Massachusetts and Maine.

The advantages of sublegal escape vents in the northern lobster fishery have been summed up by Templeman (1958) as follows:

"(a) the lessening of the temptation to sell illegal small lobsters and the reduction of the number of shorts available to fishermen who illegally retain these lobsters; (b) the saving of considerable time in picking short lobsters and crabs out of traps; (c) a decrease in injuries to short lobsters by rough handling and from encounters with larger lobsters in the confined space of the traps; (d) a probable reduction in the loss of small lobsters which may be eaten by cod and other fishes, either on their way down from the surface after being discarded, or because they have been distributed on the bottom, in daylight, in unfamiliar territory without shelter; and (e) if the traps were built with wide spaces all over them, an increase in hauling efficiency, since traps with fewer laths and less ballast, and with wider spacing all over the trap, would be more stable and survive better under turbulent conditions. It is very likely also that this greater stability would increase the catch when the traps are fished in wave-disturbed shallow water."

Sublegal escape vents may effectively decrease ghost-fishing mortality among short lobsters, especially where the catch ratio of shorts to keepers is 10 to 15:1 (Thomas, 1973:4), but do not solve the problem within the legal range. Most of the offshore lobsters caught are of legal size. The approach here may be to have a "catch-escape vent" on each pot that is kept shut by some degradable mechanism. After a specified period of time this mechanism would deteriorate, opening the vent and rendering the pot ineffective, e.g., the cotton panel required on Washington bottom-fish pots.

Another approach to the problem of preventing ghost fishing might be to design an entirely different type of pot that does not depend on the escape-proof trapping of the lobsters. Pots of



Figure 2.—An offshore lobster using a discarded 55-gallon drum as a shelter. Photo taken from a submersible at 200 m in Veatch Canyon.

this variety are used in a number of fisheries where the target animal demonstrates positive thigmotactic response, e.g., eels, octopus, and spiny lobsters (Von Brandt, 1964:58). In the spiny lobster, *Panulirus argus*, fishery of Florida, this type of pot is sometimes constructed out of discarded gasoline drums (Smith, 1958:26).

We coined the name "habipot" for a type of pot that does not depend primarily upon bait attraction or escape-proof trapping of the lobsters but instead captures lobsters by offering an attractive shelter (Fig. 2). Pots of this conceptual design would not ghost fish, and could possibly fish selectively since different-size lobsters apparently prefer different shelters (Cobb, 1971). Unfortunately we were not able to test this concept adequately because of time constraints.

The papers that follow present the results of our field and laboratory experiments.

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Ghost Fishing of Vented and Unvented Lobster, *Homarus americanus*, Traps

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R. A. CLIFFORD, and R. J. SMOLOWITZ

ABSTRACT—Field experiments were conducted in waters near Boothbay Harbor, Maine, and Woods Hole, Mass., with 40 inshore-type lobster traps. Twenty of the traps were fished normally from the surface and 20 were left on the bottom and routinely surveyed by divers. Half of the traps in each group were fitted with sublegal escape vents. Catch-escape panels were also tested. Surface-hauled traps caught 3,425 lobsters in 53 sampling periods; 28 percent of the lobsters had one or more types of body damage. The "ghost" traps caught 456 lobsters during the same period; 25 percent of the lobsters died by the end of the experiment.

INTRODUCTION

Pot-related interactions and mortality of the American lobster, *Homarus americanus*, have long been subjects of concern to lobster fishermen and state and federal fisheries research and management personnel. Information on nonselective and destructive fishing methods is required to provide information to coastal states from Maine to North Carolina regarding the management of both inshore and offshore lobster stocks.

This report presents the results of 11 months of study of lobster behavior, mortality, and emigration-immigration, regarding commercial trap gear in the Boothbay region of Maine (study Phases I and II) and Woods Hole, Mass. (study Phase III). The study was supported by NOAA's National Marine Fisheries Service (NMFS), Northeast Fisheries Center, Woods Hole, Mass., and the Manned Undersea Science and Technology Office, Rockville, Md.

The primary objective of this study

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was to define the effect of conventional pots and "ghost" pots on trap-related mortality, and to assess the effectiveness of escape vents on reducing mortality. Ghost pots are defined in this study as pots that cannot be retrieved by surface-oriented fishermen, due either to the pot's becoming "snagged" on the ocean bottom or its line being severed from the surface buoy. A secondary objective was to relate the trapping behavior of the lobster to its ecology and changes in certain environmental parameters.

MATERIALS AND METHODS

Study Area

The area selected for conducting the first and second phases of the lobster-potting study was the east side of Damariscove Island, 6 nautical miles south of Boothbay Harbor, Maine (Fig. 1). The inshore lobster population of the Boothbay region has been the subject of investigation by NMFS and the Maine Department of Sea and Shore Fisheries since 1966. Damariscove Island was the site of an extensive underwater ecological study by NMFS during 1967-72, providing a data base for the sampling design and methodology



Figure 1.—Phases I and II study area, Damariscove Island, Maine.

of this study. The Damariscove Island lobster habitat is considered representative of inshore lobster habitats for the Gulf of Maine (Cooper et al., 1975).

Damariscove Island is 1.3 nautical miles long by 0.3 miles wide (greatest width) and glacially formed. The ocean bottom in the study area is primarily bedrock to a depth of 10-15 m (35-50 feet), followed by a sand bottom with occasional outcrops of bedrock (Fig. 2). Glacial rock deposits are scattered primarily along the bedrock-sand interface.

The third phase of this study was conducted on the west side of the Weecket Islands, 5 miles west of Woods Hole, Mass., on the northern side of the Elizabethan Island chain (Fig. 3). This study area was similar to the Maine study area, with bedrock extending from the island to a depth of about 10 m where a sand substrate continued beyond the study area.

The rock substrate at Damariscove Island to depths of 18-20 m was covered with sparse to dense concentrations of attached algae, primarily *Agarum*, *Alaria*, *Ascophyllum*, *Chondrus*, *Fucus*, and *Laminaria*. Over 50 percent of all exposed surfaces of rocks

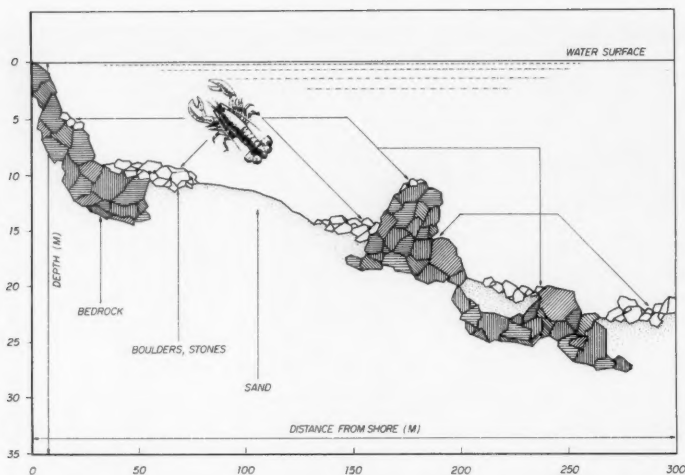


Figure 2.—Representative topography of ocean bottom and lobster habitat for lobster-potting study areas.

and boulders are encrusted with the coralline algae *Lithothamnium*. At greater depths only sparse concentrations of attached algae are present. A representative cross-section of the bottom topography in the study area is presented in Figure 2.

Rocky areas in the Massachusetts study area (Fig. 3) were primarily covered with assemblages of *Codium* sp., soft corals, and encrusting sponges. Sandy areas were notably barren of attached algae and other macrobenthic organisms.

Distribution of Catch Gear

To standardize the availability of lobsters to the various categories of catch gear it was necessary to fish the lobster pots at approximately equal distances from the rocky substrate within which the local lobster population is sheltered (Cooper et al., 1975). Figures 4 and 5 portray the distribution of experimental fishing gear regarding depth and bottom type for both study areas. Data on population density, size, and sex structure of the Damariscove Island population, as determined from the NMFS studies from 1967 to 1972, will be presented for comparative purposes later in this report.

The potting behavior-mortality study was conducted in three phases. Phases I

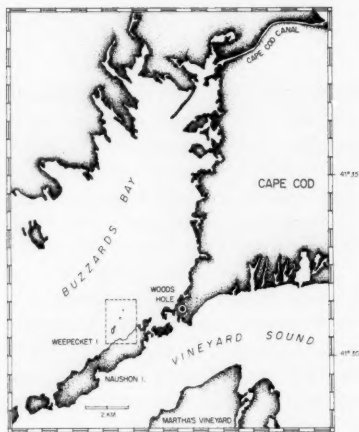


Figure 3.—Phase III study area, Weepeket Islands, Mass.

and II were in Maine, and Phase III in Massachusetts. Phase I encompassed the colder months of the year, January-May (1973); Phase II the warmer months, May-September (1973). Phase II was initiated with the dive team removing all ghost-pot contents while pots remained on the bottom, and rebaiting with redfish, *Sebastes marinus*, racks (carcass minus lateral fillets of flesh). The location of the ghost-pot trawls was not altered

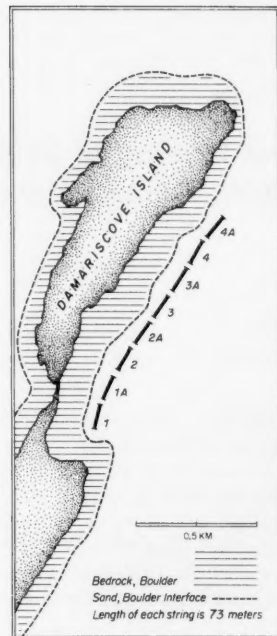
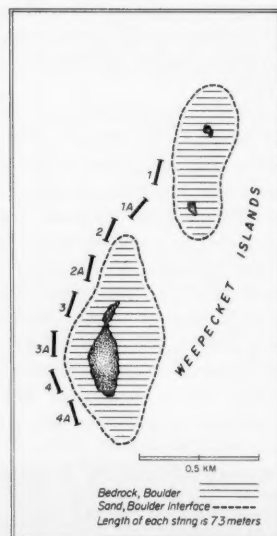


Figure 4.—Distribution of surface-hauled and ghost-pot strings at Damariscove Island, Maine.

Figure 5.—Distribution of surface-hauled and ghost-pot strings at Weepeket Islands, Mass.



from Phase I to Phase II. All biodegradable links were rearmed and sublegal escape vents cleared of any fouling debris between these first two phases. Phase III was begun in May 1974 in Massachusetts and concluded in August 1974.

Description of Trawls and Pots

Table 1 presents the four categories of catch gear fished in the two study areas along the rock-sand interface or on the sand bottom within 30 m of this interface. Eight five-pot trawls were fished during each phase. Four trawls of conventionally hauled pots were marked at the surface with stranded lobster buoys; two trawls had standard commercial-type pots without experimental escape vents, and two trawls had escape vents (sublegal escape vents and biodegradable panels). The remaining four trawls were fished in a "ghost-pot" mode without surface buoy markers; two trawls were composed of commercial pots without escape vents, and two had the escape vents. Figures 4 and 5 illustrate the alternate sequence of fishing conventionally hauled versus ghost pot trawls.

Each ghost pot was firmly fixed to the ocean bottom by winding 100-mm (0.305-inch) dacron trawl line around rock outcrops or large boulders and increasing the ballast of the pots with four 900-g (2-pound) bricks affixed to the base laths on opposite sides of the trap. Each pot was marked to designate pot and trawl number. Standard parlor-type commercial pots (Fig. 6), purchased new from a Maine manufacturer, were used for this study. Basic measurements were: length—91 cm (36 inches), top width/bottom width—63 cm (25 inches), height—33 cm (13 inches). The pots were of oak frame construction with 2.5-cm (1.0-inch) oak laths spaced 2.5-3.3 cm (1.0-1.3 inches) across the top and bottom. Sides were of 2.5-cm (1.0-inch) mesh vinyl-coated wire. Entrance rings of 14-cm (5.5-inch) diameter were located on both sides of the kitchen. Entry to the parlor was through a "skate-mouth" head (no ring at the opening). Normal lath-spacing on pots ranged from 2.5 to 3.3 cm (1.0 to 1.3 inches).

Table 1.—Pot design characteristics for study Phases I, II, and III.

Trawl no.	Fishing mode	Escape vent	Degradable panel	Mean depth (m)	Pot no.
Phases I and II—Maine					
1	Ghost	No	No	12	21-25
2	Ghost	Yes	Yes	15	16-20
3	Ghost	Yes	Yes	18	11-15
4	Ghost	No	No	18	26-30
1A	Conventional	No	No	12	36-40
2A	Conventional	Yes	Yes	15	1-5
3A	Conventional	Yes	Yes	18	6-10
4A	Conventional	No	No	18	31-35
Phase III—Massachusetts					
1	Ghost	Yes	No	14	66-70
2	Ghost	No	No	14	76-80
3	Ghost	No	No	14	71-75
4	Ghost	Yes	No	14	61-65
1A	Conventional	No	No	14	56-60
2A	Conventional	No	No	14	51-55
3A	Conventional	Yes	No	14	46-50
4A	Conventional	Yes	No	14	41-45

Escape Vents

Vents were of two basic types (Fig. 6). The first, considered a sublegal escape vent and used in the Maine study, was constructed by removing an oak lath on the end of the parlor, leaving a 3.8- to 4.3-cm high ($1\frac{1}{2}$ - to $1\frac{1}{16}$ -inch) opening. During the Massachusetts study the opening in the oak laths was blocked, and a panel made of various materials with a 4.5-cm high and 15.2-cm long ($1\frac{3}{4}$ ×6-inch) opening was

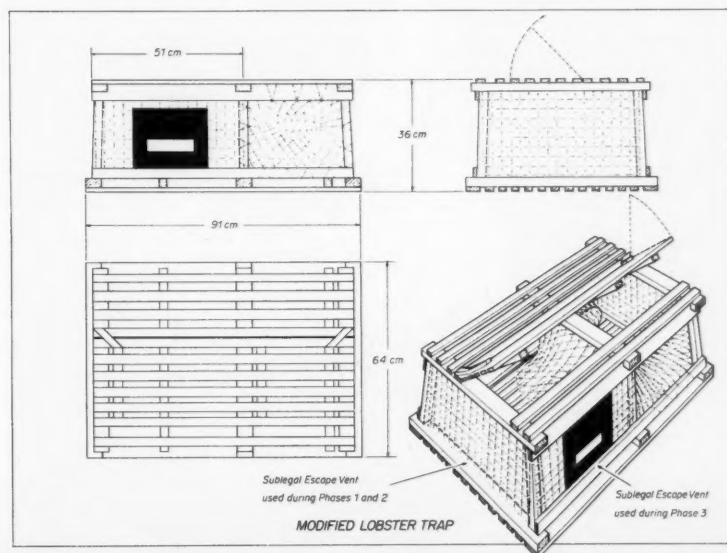
affixed to the side of each experimental trap.

Experimental traps of the Maine study were also modified by cutting 10×15 -cm (4×6 -inch) openings on three sides of the parlor, and a panel with a degradable link or latch was affixed over the openings. All panels were constructed of the same material as the parlor sides of the pot and affixed to the pot walls at the bottom with two stainless steel rings. Each panel was fastened at the top by one of the various types of degradable material (jute, cotton, leather, manila, iron wire, iron-copper wire interwoven, and wool). Panels were fastened in such a way that upon breakdown of the degradable link the panel would open in an outward or inward direction. A detailed description of the sampling design, material used, and analysis of results of the degradable escape vents is presented by Blott (1978).

Setting and Hauling of Surface-Buoyed Pot Trawls

Each of the four conventional pot trawls was hauled on a weekly basis using standard commercial hauling gear. A schematic of basic setting

Figure 6.—Schematic of lobster pot used during study, with escape vent.



methods and measurements of trawls is given in Figure 7. Using landmarks on nearby islands and the vessel's depth recorder, trawls 1A-4A were fished at specific locations and at the desired distance from the rock-sand interface in their proper order along the linear array of eight trawls (Figs. 4 and 5). As each pot was hauled aboard the boat, the old bait was discarded and four to five redfish "racks" were strung on the bait string.

The physical condition of each escape panel, and associated degradable linkage material when used, was noted as well as the relative position of the panel on the parlor.

Numbers of lobsters, crabs, sea urchins, and various species of finfish were recorded from each pot. Carapace length and width in millimeters, sex, handedness, presence of eggs and maturity stage, old and new damage to the body (obvious punctures or breaks

in the exoskeleton), and missing appendages were noted for each lobster. Legal lobsters were removed from the study area, sublegals were returned to the water. All catch data and lobster measurements were recorded by trawl and pot number.

Surveying Ghost-Pot Trawls

The two-man dive teams, using scuba, surveyed the four ghost-pot trawls weekly. Ghost pots were baited only at the beginning of the experiment and were left on the ocean bottom to simulate a realistic ghost-fishing mode. Divers used underwater writing tablets to record their observations and measurements (Fig. 8). Occasionally underwater lights were required to visually inspect the inner portions of the pots. The Massachusetts portion of the study was characterized by 1- to 2-knot tidal currents and poor underwater visibility of 1-2 m; the Maine study site usually had 3-5 m of visibility and little current (less than 0.2 knots).

The first diver survey of the ghost-pot trawls was conducted approximately 1 week after their placement on the ocean bottom. Each lobster found in a pot was given a color coded (red, blue, white, or yellow) and punch-hole coded, 1.3-cm wide (0.5-inch), rubber band on each cheliped to identify the individual lobster, its pot of observed capture, and trawl number. Lobsters recorded during the first week while bait remained as an attractant were classified as initial lobsters, those recorded later were classified as immigrants. Rubber bands were positioned proximally to the dactyl portions of the chelipeds so as not to deactivate the normal functions of the large claws. One of the five sections of the tail fan was given a 3-mm (0.1-inch) punched hole to serve as a secondary mark for experimental lobsters and denote its respective pot, i.e., 1, 2, 3, 4, or 5, within that trawl string. A hole punched in the tail fan is maintained through at least one moult and served to distinguish an experimental lobster from a previously unmarked lobster through the following moulting season, or in case of lost coded bands through band

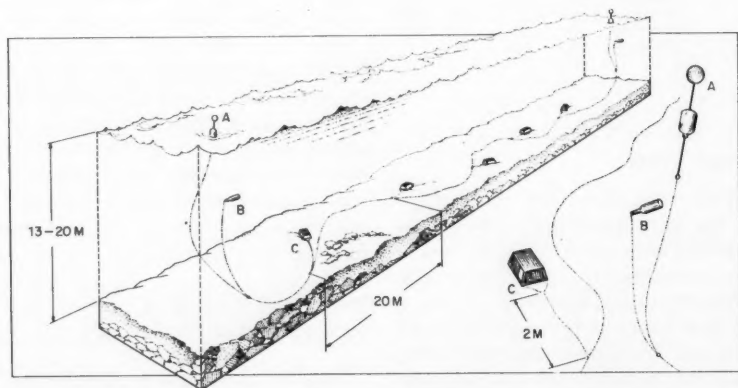
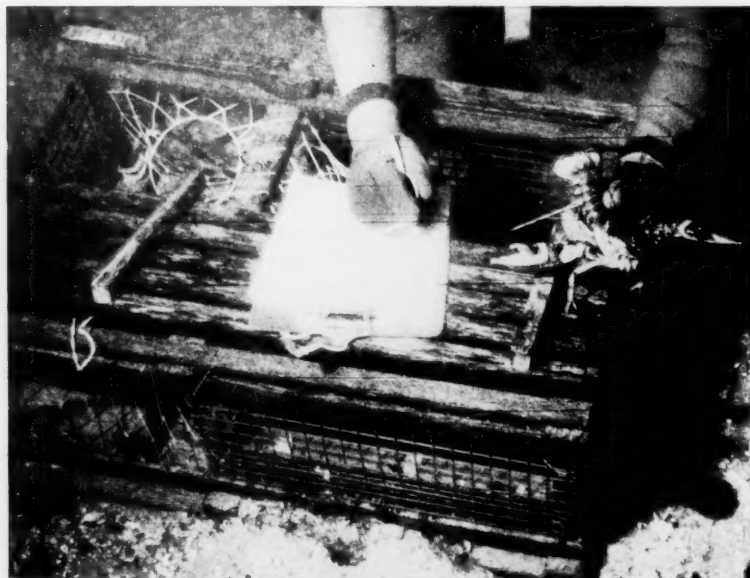


Figure 7.—Schematic of pot trawl set. A. Marker buoy. B. Float or toggle. C. Trap and gangion.

Figure 8.—Diver surveying ghost-pot catch.



breakdown or loss of chelipeds. Each dive team carried the necessary equipment on survey dives to mark new lobsters in ghost pots.

Lobsters from the ghost pots were removed carefully and individually by the dive team so as not to create a "chain reaction" of aggressive behavior among the pot's occupants. Each marked lobster was examined as to sex, carapace length, handedness, tail-fan punch, cheliped band color and punch mark, and noticeable injuries. Unmarked lobsters were marked and the same measurements and observations recorded. Pot and trawl number were recorded for each pot examined. The compartment was also noted, i.e., the kitchen or parlor.

The presence of other macrofauna (crabs, fish, sea urchins, etc.) within the pot was recorded along with observations on intraspecific behavior. A detailed examination of the parlor and kitchen of the trap and the ocean bottom within 4 m (12 feet) of the trap was conducted to assess the fate of missing lobsters. The exoskeleton breaks down into its component parts when a lobster dies, and pieces of shell in the area are sometimes the only direct evidence of the fate of a missing individual.

Night dives were made periodically throughout the Maine portion of the study to 1) measure directly the sex ratio and size distribution of the nocturnally active lobsters in the immediate vicinity of the experimental and conventional pot trawls, 2) observe the behavior of lobsters and other fauna within the pots at nighttime, and 3) locate individuals missing from the pots and measure the distance from the escaped pot to their shelter. Underwater lights were used to search lobster burrows, rock crevices, sand flats, etc., for marked individuals and to enable the dive team to accurately sample the nocturnal individuals.

Environmental Monitoring

In-situ measurements of water temperature, dissolved oxygen, pH, and conductivity were made of the bottom water mass during each week of the Maine study. Salinity was determined from the temperature-conductivity

Table 2.—Numbers and mean carapace lengths (mm) of male and female lobsters taken during 13 night dives at Damariscove Island, 1973.

Date	Study phase	Males		Females		Total no.	C.L. sexes combined (mm)
		No.	C.L. (mm)	No.	C.L. (mm)		
13 Mar	I	10	71.3	9	75.8	19	73.4
24 Apr	I	22	67.5	13	68.5	35	67.9
8 May	II	16	70.2	23	69.2	39	69.6
16 May	II	61	70.0	47	69.7	108	69.9
11 Jul	II	33	70.0	15	71.7	48	70.5
Total		142	69.7	107	70.2	249	69.9

¹57% of sample.

²43% of sample.

measurements. These four monitoring systems compose the Martek Mark I Water Quality Monitoring System¹. Each sensor was calibrated at the beginning of the study and halfway through the study. Accuracy of the conductivity meter was ± 0.2 parts per thousand, temperature was $\pm 0.1^\circ\text{C}$, dissolved oxygen was ± 0.4 parts per million at temperature of calibration, and pH was ± 0.1 . The Martek sensor package was lowered to 15 m at the center of the study area each week and the above measurements recorded.

RESULTS AND DISCUSSION

Natural Population

Samples of the nocturnally active (leaving shelter) portion of the natural lobster population were collected on 13 night dives during study Phases I and II. Sample statistics are presented in Table 2. Night dives were conducted between 2100 and 0400 hours, when nocturnal activity is at its peak (Cooper and Uzmann, 1977). Nocturnally active lobsters were of sufficient size (45-mm carapace length and larger) to be easily recognized by the dive team and captured; thus these samples are considered representative of the natural population that leave their shelters at night and are subject to capture by lobster pots.

A total of 249 lobsters were collected during the night dives in March, April, May, and July, 1973. The mean carapace length for males and females was similar throughout Phases I and II.

¹Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

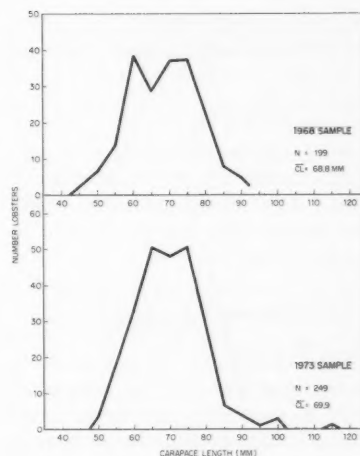


Figure 9.—Frequency distribution of lobsters (sexes combined) sampled from the nocturnally active population at Damariscove Island, 1968 and 1973, grouped in 5-mm intervals.

Likewise, the mean carapace length for males and females was similar by sampling date. Average size for males and females for the 13 samples was 69.7 mm and 70.2 mm, respectively. Figure 9 presents a length-frequency distribution of all lobsters from the night collections (1973), sexes combined. Sizes ranged from 41 to 117 mm.

Of the 249 lobsters collected, 142 (57 percent) were males and 107 (43 percent) were females—not significantly different from a 50:50 ratio (χ^2 (1 df)=2.97, $P>0.5$).

To further define the sex ratio and size characteristics of the nocturnally active population, an examination of similar data collected by divers at Damariscove Island in 1968 (Cooper et al., 1975) was made. A total of 199 lobsters was collected on 18 March 1968 ($N=18$) and 15 and 16 August 1968 ($N=181$). Sex ratio was 50:50 ($N\delta=99$, $N\phi=100$). Males averaged 69.5 mm and females 68.2 mm, all samples combined, not significantly different from the overall 69.7 mm and 70.2 mm for males and females sampled in 1973. Sizes ranged from 45 to 91 mm. A frequency distribution of sizes, sexes combined, is presented in Figure 9.

Chi-square tests on these combined

nocturnal collections (1968 and 1973, $N=448$) show that the observed sex ratio (males 46.4 percent, females 53.8 percent) does not differ significantly from 50:50 (X^2 (1 df) = 2.89, $P>0.05$). For this study we conclude that the nocturnally active lobsters at Damariscove Island are evenly composed of males and females that average 70 mm in carapace length.

Surface-Hauled Pot Catch

Catch Statistics

A total of 3,425 lobsters were taken over 53 sampling periods of study Phases I, II, and III. Complete catch statistics for these lobsters are given in Appendix A. Mean carapace length by sex, pot type (vented and nonvented), and sampling data for surface-hauled pots are presented in Tables 3, 4, and 5 for Phases I, II, and III.

Mean carapace lengths of males and females by trap type and study phase were similar. Similarly, mean carapace length by sex was relatively constant through the sampling interval for each study phase. Consequently, a mean carapace length for all lobsters, sexes combined, by pot type and study phase was determined (Tables 3-6).

Vented pots in all three phases caught larger lobsters and fewer lobsters (Table 6, Figs. 10, 11, 12). Mean carapace lengths of the non-vented pot catches compared with vented pot catches within each phase were different. (Phase I: $t_{(df=730)}=3.52$, $P<0.01$. Phase II: $t_{(df=843)}=3.91$, $P<0.01$. Phase III: $t_{(df=1,846)}=17.24$, $P<0.01$.) These highly significant differences indicate that the sublegal escape vents permitted the escape of relatively large lobsters compared with those that can escape the nonvented pots. Figures 10 and 11 demonstrate that vented pots retained fewer lobsters less than 75 mm (Phase I) and 80 mm (Phase II) in carapace length than the nonvented pots. Similarly, Phase III vented traps retained fewer lobsters 80 mm and smaller than nonvented pots (Figure 12). Krouse and Thomas (1975) reported similar results during tests of pots with 45-mm and 37-mm escape vents.

Table 3.—Inventory of surface hauled traps from study Phase I.

Sampling date	Nonvented						Vented					
	Total			Males			Total			Males		
	No.	C.L.		No.	C.L.	%	No.	C.L.		No.	C.L.	%
26 Jan.	47	76.4		25	77.5	47	46	75.7		26	77.4	43
5 Feb.	28	75.6		14	74.6	50	20	74.4		9	75.1	55
14 Feb.	14	74.6		10	74.9	4	7	73.6		3	73.0	43
20 Feb.	13	74.9		5	71.4	8	—	—		—	—	—
26 Feb.	7	70.4		1	82.0	6	2	73.0		2	73.0	—
9 Mar.	1	77.0		1	77.0	—	—	5	76.0		3	76.0
15 Mar.	2	76.5		—	—	2	7	73.4		1	91.0	86
20 Mar.	4	81.3		2	79.0	2	12	75.4		9	73.7	25
28 Mar.	5	71.2		3	70.3	2	2	72.5		—	—	100
3 Apr.	7	73.4		5	72.6	2	17	75.6		10	74.7	41
13 Apr.	51	75.5		21	75.5	30	26	78.2		13	78.8	50
18 Apr.	13	77.2		6	75.7	7	18	75.7		6	74.0	67
24 Apr.	24	73.4		15	74.9	9	31	77.0		18	76.3	42
30 Apr.	35	73.7		18	72.6	17	43	74.7		20	73.0	53
7 May	65	74.6		28	74.2	37	32	77.2		16	76.3	50
14 May	41	74.4		20	73.7	21	27	76.7		16	76.7	41
23 May	44	72.4		24	72.5	20	74.8	76.3		76.1	76.4	
Average	74.6			74.4		74.8	76.3			76.1		
Total	401			198		203	331			172		48

Table 4.—Inventory of surface hauled traps from study Phase II.

Sampling date	Nonvented						Vented					
	Total			Males			Total			Males		
	No.	C.L.		No.	C.L.	%	No.	C.L.		No.	C.L.	%
4 June	28	75.7		13	74.6	15	35	77.8		16	76.7	54
11 June	21	73.5		14	72.5	7	29	75.8		15	76.4	48
18 June	19	72.5		6	74.7	13	18	76.5		6	75.2	67
27 June	34	75.6		20	74.7	14	21	77.3		5	74.4	76
3 July	14	70.8		8	72.9	6	38	72.4		15	72.2	61
10 July	34	76.2		16	75.1	18	22	78.4		10	74.0	55
17 July	48	75.5		22	74.5	26	19	77.3		10	77.1	67
23 July	31	75.5		13	74.2	18	24	80.0		8	81.8	67
31 July	28	77.9		15	78.3	13	17	81.4		10	81.4	61
6 Aug.	38	76.6		15	77.7	23	32	76.7		15	75.7	52
17 Aug.	37	77.2		17	77.4	20	32	83.1		10	86.0	69
21 Aug.	43	76.4		24	75.5	19	35	81.2		12	78.4	66
28 Aug.	52	79.7		22	78.5	30	34	78.0		19	77.8	44
30 Aug.	40	74.6		15	73.5	25	22	78.3		12	77.9	42
Average	76.1			75.5		76.5	78.1			77.3		
Total	467			220		247	378			163		57

Table 5.—Inventory of surface hauled traps from study Phase III.

Sampling date	Nonvented						Vented					
	Total			Males			Total			Males		
	No.	C.L.		No.	C.L.	%	No.	C.L.		No.	C.L.	%
14 May	29	71.3		19	73.2	10	35	76.1		19	76.8	46
21 May	67	74.6		43	74.5	24	30	78.4		17	79.4	43
23 May	27	72.0		13	72.2	14	22	76.4		10	77.6	55
28 May	109	72.4		46	73.3	63	30	78.4		12	77.8	60
30 May	47	71.8		24	72.9	23	15	78.5		9	79.6	40
3 June	31	72.1		19	72.8	12	17	78.1		5	77.8	71
7 June	53	72.0		21	72.1	32	21	79.3		10	79.4	52
12 June	27	73.3		17	72.8	10	29	79.3		16	79.8	45
14 June	60	73.5		27	73.0	33	15	78.0		9	77.2	40
18 June	74	75.1		45	75.8	29	25	78.7		12	80.7	52
24 June	94	75.2		46	75.5	48	37	79.8		21	80.4	43
27 June	121	74.6		69	75.0	52	34	79.4		18	80.6	47
5 July	99	74.4		50	74.8	49	—	—		—	—	—
10 July	82	75.1		38	75.3	44	33	81.0		17	81.2	48
16 July	85	73.1		40	72.1	45	24	78.9		4	78.0	83
22 July	59	75.1		25	75.3	34	23	78.8		4	76.8	83
30 July	55	75.4		29	74.2	26	19	79.7		6	78.7	67
5 Aug.	37	72.7		12	69.6	25	—	—		—	—	—
6 Aug.	22	74.6		13	74.5	9	17	79.5		6	78.2	65
12 Aug.	51	75.8		22	74.2	29	35	80.1		11	77.8	68
19 Aug.	57	74.7		25	75.0	32	19	78.6		8	78.6	58
23 Aug.	63	73.8		31	72.5	32	19	77.3		6	76.8	68
Average	74.0			74.0		73.9	78.8			79.0		
Total	1,349	73.80		674	74.03	675	499	78.79		220	79.02	56

Table 6.—Summary of surface pot catch by phase, pot type, and sex.

Table 1. Summary of surface pot catch by phase, pot type, and sex.													
Phase	Trap type	Sublegal/Legal											
		Males			Females			Sexes combined			<81 mm	≥81 mm	% Sub-legal
		No.	C.L.	SD	No.	C.L.	SD	No.	C.L.	SD			
I	Vented	172	76.1	5.56	159	76.4	6.48	331	76.3	6.01	272	59	82.2
	Non-vented	198	74.4	6.08	203	74.8	7.60	401	74.6	6.89	339	62	84.5
II	Vented	163	77.3	6.87	215	78.6	8.32	378	78.1	7.74	285	93	75.4
	Non-vented	220	75.5	6.50	247	76.5	7.56	467	76.1	7.09	385	82	82.4
III	Vented	220	79.0	3.82	279	78.6	3.87	499	78.8	3.85	374	125	75.0
	Non-vented	674	74.0	5.57	675	73.9	5.94	1,349	74.0	5.76	1,196	153	88.7

Table 7.—Observed damage of surface pot caught lobsters by study phase and type of damage. Other damage category includes broken rostrum, cracked carapace or abdomen, missing or broken antennae, etc. Data is listed in numbers and percent (in parenthesis).

Study phase	No. lobsters	Missing one claw	Missing both claws	Damaged one claw	Damaged both claws	Regenerate one claw	Regenerate both claws	Missing legs (one or more)	Damaged uropods	Other damages	Total number damaged lobsters
I	732	55 (7.5%)	9 (1.2)	10 (1.4)	1 (0.1)	50 (6.9)	1 (0.1)	11 (1.6)	3 (0.3)	11 (1.6)	136 (18.6)
II	845	82 (9.7%)	11 (1.3)	16 (1.9)	2 (0.2)	48 (5.7)	0 (0.0)	17 (2.0)	4 (0.4)	16 (1.9)	183 (21.7)
III	1,848	204 (11.0%)	22 (1.2)	157 (8.1)	21 (1.2)	132 (7.1)	1 (0.0)	112 (6.0)	42 (2.4)	61 (3.3)	628 (35.0)
Total	3,425	341 (10.0%)	42 (1.2)	183 (5.4)	24 (0.7)	230 (6.7)	2 (0.0)	140 (4.1)	49 (1.2)	88 (2.4)	947 (27.6)

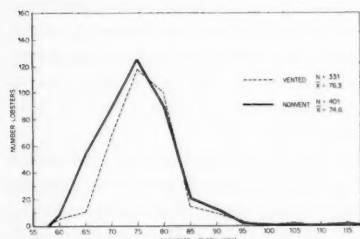


Figure 10.—Phase I. Surface-pot catch length-frequency, by 5-mm increments, of vented and nonvented pots (sexes combined).

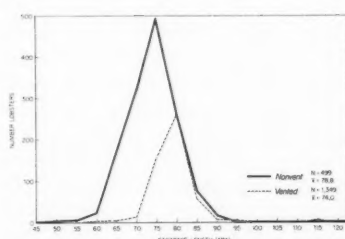
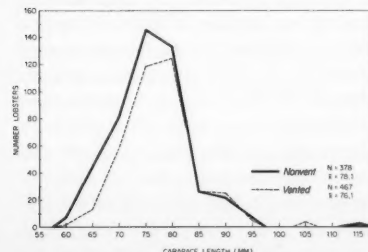


Figure 12.—Phase III. Surface-pot catch length-frequency, by 5-mm increments, of vented and nonvented pots (sexes combined).

Figure 11.—Phase II. Surface-pot catch length frequency, by 5-mm increments, of vented and nonvented pots (sexes combined).



Comparisons of sex ratios of the catch by pot type within study phase were similar at the 5 percent level (Table 6) with the exception of Phase III. Here, females dominated the vented pot catch (56 percent females, X^2 (1 df) = 4.80, $P < 0.05$). The reason for a predominance of females in the vented pots of Phase III is unknown.

Sublegal to Legal Ratio

Vented pots caught fewer sublegal lobsters (<81 mm) than nonvented pots

Table 8.—Observed damage, judged new or old, for surface hauled lobsters from study Phase III, 30 July to 19 August 1974. Data given in numbers and percent.

Item	Total lobsters	With old damage	With new damage	Total damaged lobsters
Vented	91	36 (37.6%)	7 (7.7)	39 (42.9)
Nonvented	221	95 (43.0%)	21 (9.5)	108 (48.9)
Total	312	131 (42.0%)	28 (9.0)	147 (47.1)

in each study phase (Table 6). The differential in catch was greatest for Phase III (75 percent sublegals, vented—89 percent sublegals, nonvented) with a 45-mm (1 3/4-inch) escape vent and a 19-mm (3/4-inch) difference in lath spacing between pot types. During Phases I and II the percentage of sublegals in vented pots was only slightly less than in nonvented pots. Correspondingly, the percentage of legal lobsters (≥ 81 mm) caught by the two trap types was nearly similar for Phases I and II and dissimilar for Phase III, where legals composed 25 percent of the vented pot catch compared with 11 percent for the nonvented pots.

Incidence of Damage

All damage on lobsters caught by surface-hauled pots is summarized by study phase and type of damage in Table 7. For all phases combined, 27.6 percent (947 lobsters) had one or more types of body damage; 18.6 percent in Phase I, 21.7 percent in Phase II, and 35.0 percent in Phase III. The most common types of injuries were damaged, regenerate, or missing claws.

From 30 July 1974 to 19 August 1974, 312 lobsters from out surface-hauled pots were examined for "new" versus "old" injuries during study Phase III (Table 8). New injuries were identified by open wounds with no evidence of healing. This category of injury is assumed to have occurred during aggressive encounters with other lobsters in the pot. Old injuries were characterized by healing scar tissue or the presence of a regenerating body part. Of the lobsters caught in the surface-hauled vented pots, 8 percent had "new" damage, compared with 9.5 percent from the nonvented pots (Table 8). Incidence of newly damaged lobsters was similar for vented and

nonvented pots. Also, the percentage of "old" damage was similar for vented and nonvented pots.

Comparison of Surface-Hauled Pot Catch and Natural Population

Size distributions and sex ratios of the diver-collected samples of lobsters from Damariscove Island and the surface-hauled pot catches (Phases I and II) were compared to judge the representative nature of the latter catch technique. Sex ratios of the combined diver collections from 1968 and 1973 (46.4 percent males, 53.8 percent females) and the surface-hauled pot catch (50.5 percent males and 49.5 percent females, Phase I; 45.3 percent males and 54.7 percent females, Phase II) were similar.

The surface-hauled pot catch yielded lobsters of a greater average size than the diver technique of sampling. Pot catches averaged 75-79 mm carapace length compared with 70 mm for diver-collected lobsters. Pots rarely caught lobsters less than 60 mm, whereas diver collected nocturnally active lobsters as small as 45 mm. We believe that the 45- to 60-mm lobsters did enter the surface-hauled pots but were not retained because of the lath spacing and escape-vent openings. The surface-hauled pots demonstrated only partial retention of 60- to 70-mm lobsters. Krouse (1973) fished surface-hauled pots with 25-mm square wire meshing in the same general study area in Maine. His catch length-frequencies reveal substantial numbers of lobsters in the 45- to 60-mm range, with an annual average carapace length of 68 mm. We conclude that our surface-hauled pots caught a representative proportion of the nocturnally active males and females but were selective for the larger individuals.

The total catch by vented traps was significantly less than by nonvented traps for all study phases (Tables 3-6). Again, the superior catches of nonvented traps is probably due to the greater ability of sublegal lobsters to emigrate from the traps with wider escape vents. The greater differential in

size of escape vents of study Phase III (19 cm) compared with Phases I and II (13 mm) resulted in a proportionally smaller catch by vented traps in Phase III. Vented traps caught 83 and 81 percent of the lobsters taken by nonvented traps in Phases I and II and only 37 percent in Phase III.

Catch Per Haul

Catch per haul trends were noted for a general indication of lobster trapability and a possible correlation between bottom-water temperature and catch.

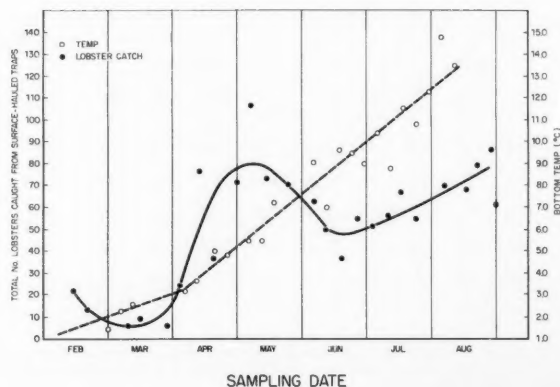


Figure 13.—Catch of lobsters from surface-hauled pots at Boothbay Harbor, and water temperature at 15-m depth. Sampling interval variable from 2 to 12 days.

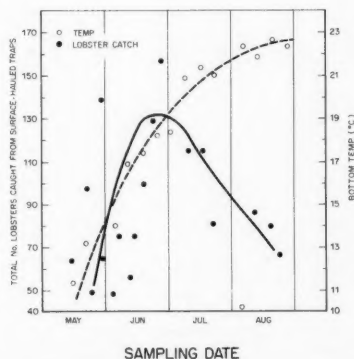


Figure 14.—Catch of lobsters from surface-hauled pots at Weepecket Islands, Mass., and temperature from 5-m at Woods Hole, Mass. Sampling interval variable from 2 to 13 days.

Set-over days versus catch will not be analyzed in this report.

Lobster catch in Phases I and II generally increased with increasing water temperature (Fig. 13). The decreased catch in late June and early July is probably due to a sharp increase in commercial fishing in the study area at this time and to decreased mobility, and therefore trapability, of the lobster prior to and post-moulting (McLeese and Wilder, 1958).

Lobster catch in Phase III increased with temperature from May through June, then decreased suddenly in July and August (Fig. 14). This drop may also be related to decreased mobility with regard to moulting.

Egg-bearing Females

Of the 818 female lobsters taken with surface-hauled pots during Phases I and II, only two were egg-bearing, 117- and 139-mm carapace lengths. Krouse (1973), using ovary stage and presence of spermatophores, concluded that the majority of female lobsters along the coast of Maine do not reach sexual maturity until 90-mm carapace length. Thomas (1973) sampled the population of Maine lobsters in the 81- to 127-mm size range at commercial pounds, and found the average size of berried females to be 102 mm (range 83-127 mm).

During Phase III, 8.4 percent of the

captured females carried external eggs, in contrast to less than 1 percent with eggs from the surface-hauled pot catches of Phases I and II. Average size of berried females ($N=155$) from Phase III was 78.0 mm, with a range of 68 to 91 mm.

Ghost-Pot Catch

Summary of Catches

Catch data collected by the dive team during Phases I, II, and III are presented in Table 9. The data are grouped by study phase, pot type, sex, sexes combined, and percent sublegal. Only original sightings (first capture) are presented. Catch data for each study phase were grouped into vented and nonvented categories for an assessment of the experimental 38- to 43-mm (Phases I and II) and 45-mm escape-vent openings in contrast to the conventional 25- to 33-mm lath spacing.

Mean sizes of male and female lobsters by pot type are similar for Phases I and II, thus these data were combined (Table 9). Mean size of lobsters (sexes combined) from vented and nonvented pots for Phases I and II were also found to be similar (Phase I, $t_{(df=61)}=1.77$, $P>0.10$; Phase II, $t_{(df=142)}=0.96$, $P>0.10$). Thus these data (males and females combined) for vented and nonvented pots were combined by study phase (Phase I $\bar{C.L.}=74.8$ mm; Phase II, $\bar{C.L.}=72.5$ mm). We believe the reasons for statistically similar mean sizes of lobsters from vented versus nonvented pots is due to 1) the relatively small difference in spacing between conventional and experimental pots, and 2) the small numbers of lobsters captured by the ghost pots. Length-frequency distributions for these combined samples are presented in Figures 15 and 16. In Phase III the mean carapace lengths for males and females by pot type are similar (vented, $t_{(df=85)}=0.13$, $P>0.10$; nonvented, $t_{(df=160)}=1.60$, $P>0.05$). Therefore, these data are combined (Table 9). Mean size of lobsters (sexes combined) from vented pots ($\bar{C.L.}=78.3$ mm) is significantly greater than the mean size from nonvented pots ($\bar{C.L.}=76.0$ mm) with

Table 9.—Data summations of ghost-pot lobsters by phase, sex, sexes combined, and pot type.

Phase	Trap type	Males			Females			Sexes combined			Pot type combined			Sublegal/Legal		% Sub-legal
		No.	C.L.	SD	No.	C.L.	SD	No.	C.L.	SD	No.	C.L.	SD	<81 mm	≥81 mm	
I	Vented	18	75.4	4.52	16	76.8	5.62	34	76.0	5.03	63	74.8	5.92	28	6	82.3
	Non-vented	19	74.6	5.95	10	71.1	7.56	29	73.4	6.63				27	2	93.0
II	Vented	32	76.9	7.09	22	74.3	4.74	54	75.9	6.32	144	72.5	6.67	44	10	81.5
	Non-vented	51	74.6	5.78	39	75.0	8.17	90	74.8	6.88				76	14	84.4
III	Vented	53	78.4	7.14	34	78.2	7.14	87	78.3	7.14				61	26	70.1
	Non-vented	103	76.5	5.80	59	75.0	5.66	162	76.0	5.78				133	29	82.1

$t_{(df=247)}=2.74$, $P>0.01$. Size-frequency distributions for vented and nonvented pot catches (sexes combined) are presented in Figure 17.

We believe that 45-mm vent openings in Phase III, compared with the conventional 25- to 33-mm lath spacing, permitted a greater degree of escape of relatively large lobsters than was possible from the conventional pots. Therefore, vented and nonvented pot catches are not combined for Phase III.

Sex ratios for vented and nonvented pot catches for Phases I and II, and Phase III vented tested by chi square, were not significantly divergent from a 50:50 ratio. In Phase III males dominated nonvented (64 percent $\chi^2_{(df=1)}=5.55$, $P<0.05$) pot catches. These data are in contrast to the surface pot catches of Phase III, where females dominated the vented pot catch and both sexes were equally abundant in the nonvented pots.

Some unplanned loss of ghost-pot contents occurred during Phase III: pot 63 accidentally opened, releasing its contents; and on 9 July, pots 62, 64, and 65 were found empty—apparently they had been hauled and their contents removed.

Ghost pots of Phases I, II, and III retained 456 lobsters that were recorded during weekly diving inventories. Capture totals and fates of captured lobsters are summarized in Table 10.

Ghost-pot captures during Phase I totaled 63 lobsters, 47 entering pots while bait remained as an attractant, and 16 lobsters entering after the bait had disappeared. Seven lobsters were missing

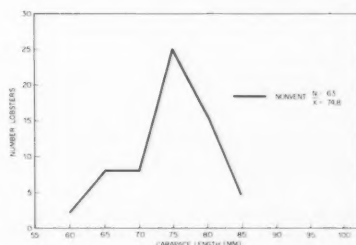


Figure 15.—Length frequency of Phase I ghost-pot lobsters by 5-mm increments, sexes and trap type combined.

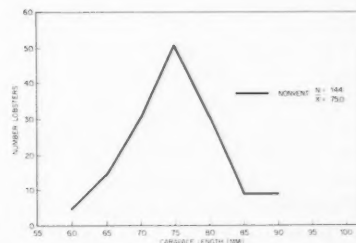


Figure 16.—Length frequency of Phase II ghost-pot lobsters by 5-mm increments, sexes and trap type combined.

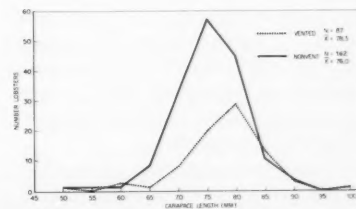


Figure 17.—Length frequency of Phase III vented and nonvented ghost-pot lobsters, sexes combined.

Table 10.—Catches and fates of captured lobsters from ghost pots of study Phases I, II, and III.

Trawl type	Total number lobsters captured	Initial captures ¹	Immigrants	Emigrants	Deaths	Missing
Phase I						
Nonvented	21	8	13	0	2 (10%)	4 (19%)
Nonvented	8	7	1	0	3 (38%)	1 (13%)
Vented	15	15	0	1	1 (7%)	1 (7%)
Vented	19	17	2	1	2 (13%)	1 (7%)
Subtotal nonvented	29	15	14	0	5 (17%)	5 (17%)
Subtotal vented	34	32	2	2	3 (9%)	2 (6%)
Total	63	47	16	2	8 (13%)	7 (11%)
Phase II						
Nonvented	64	38	26	0	8 (13%)	25 (39%)
Nonvented	26	17	9	0	12 (46%)	7 (27%)
Vented	33	7	26	0	8 (24%)	7 (21%)
Vented	21	17	4	0	4 (19%)	8 (38%)
Subtotal nonvented	90	55	35	0	20 (22%)	32 (36%)
Subtotal vented	54	24	30	0	12 (22%)	15 (28%)
Total	144	79	65	0	32 (22%)	47 (33%)
Phase III						
Nonvented	82	40	42	4	26 (32%)	26 (32%)
Nonvented	80	39	41	1	38 (48%)	26 (33%)
Vented	42	32	10	1	0 (0%)	7 (17%)
Vented	45	14	31	1	8 (18%)	22 (49%)
Subtotal nonvented	162	79	83	5	64 (40%)	52 (32%)
Subtotal vented	87	46	41	2	8 (12%)	29 (33%)
Total	249	125	124	7	72 (29%)	81 (33%)

¹Lobsters entering baited pots as opposed to entering pots after bait has disappeared.

from pots. Two lobster escapees from an intact pot were recaptured in the study area by divers, and there were eight confirmed deaths of lobsters in ghost pots.

Phase II ghost-pot catch totaled 144 lobsters, 79 entering pots while bait remained as an attractant, and 65 captured over the remainder of the phase. Missing lobsters totaled 47, of which there were no recaptures. Thirty-two lobsters were found dead in pots during this phase.

Phase III catch provided 249 lobsters, 125 entering pots while some bait remained, and an additional 124 entering during the remainder of the phase. Eighty-one lobsters were originally recorded as missing; seven of these were recaptured in the study area by our, or local fishermen's, surface pots. An additional 72 lobsters were recorded as pot-related deaths when their remains were found in our pots during diver inventories.

A history of each lobster captured by a ghost pot is given in Appendix B. Lobster-history data is grouped by study phase and pot number. Lobsters captured in each pot are listed in their

order of entry. Sex, carapace length, original condition, time of first entry, damage incurred while entrapped, and its eventual fate are noted for each individual. Dates of in situ observation and examination of each lobster are given at the top of each table. The circle symbol on a lobster's time of entrapment denotes a trap-related injury and is defined in the remarks column. All pot injuries are preceded by a capital "I" and defined. Multiple injuries occurring in pots are separated by semicolons in the remarks column and are given in the order they occurred. Any injuries found on the lobster when it was first recorded are noted as the first entry in the remarks column and are not preceded by an "I." Each lobster's time of entrapment is represented by a heavy horizontal line beginning on the inventory date that it was initially recorded and extending through the last observational day for that individual. Lobsters with lines terminating prior to the final inventory day are characterized by one of three letters: "E" represents an escape from an intact trap, "M" is a lobster missing from a trap, and "D" is a lobster found dead within the trap.

Comparison of Ghost-Pot Catch with Surface-Pot Catch and Natural Population

Ghost-pot catches of Phases I and II, by pot type, were similar to surface-pot catches in mean size and sex composition (Tables 6 and 9). Compared with the even mixture of males and females in the nocturnally active portion of the population, the ghost-pot catches were similar in sex composition (58 percent males) but were comprised of larger lobsters ($\bar{C.L.}$ ranged from 73.4 to 78.3 mm) depending upon pot type, compared with 70 mm for the nocturnally active lobsters. Relatively few lobsters less than 70 mm were retained by the ghost pots (Figs. 15 and 16) compared with the size distribution of nocturnally active lobsters (Fig. 8). We conclude that ghost pots, regardless of pot type, selectively retain large lobsters but are not selective by sex.

Nonvented ghost pots of Phase III caught 162 lobsters (64 percent males) with an average carapace length of 76 mm compared with the surface-pot nonvented catch of 1,349 lobsters (50 percent males) averaging 74 mm. Sex composition of the nonvented ghost-pot and nonvented surface-pot catches were dissimilar ($X^2_{(df=1,509)}=10.16$, $P<0.01$).

Vented ghost pots of Phase III caught 87 lobsters (61 percent males) with an average size of 78 mm compared with the surface catch of 499 lobsters (44 percent males) averaging 79 mm. Again, males composed a greater percentage of the ghost-pot catch than of the surface-pot catch. Mean sizes ($\bar{C.L.}$) of ghost-pot and surface-pot catches were similar for vented pots, $t_{(df=584)}=0.96$, $P>0.05$, and dissimilar for nonvented pots, $t_{(df=1,509)}=4.17$, $P<0.01$. Again, vents had the effect of reducing ghost-pot catches and increasing average length of ghost-pot lobsters compared with nonvented pots.

Mortality, Damage, and Escapes

Escapes. During this study there were two classes of lobster escapees from ghost pots. The first is a lobster escapee from a pot opening with the

eroding of a degradable linked panel or a pot structural failure leaving a space large enough for escapement. The second escapee class was lobsters escaping from an intact pot and later recaptured by surface pots or divers.

During Phase I, 12 lobsters escaped when the catch-escape panels on three pots opened; 26 lobsters escaped during Phase II when the panels on nine pots opened. During Phase III, a panel on pot number 63 accidentally opened and eight lobsters were released. Catch-release panels served as an effective means to release captured lobsters.

There were eight confirmed escapees from intact lobster pots, two from Phase I and six during Phase III. Both Phase I lobsters (75 and 73 mm) were from vented pots. Of the six Phase III escapees, five (64, 55, 73, 77, and 78 mm) were in nonvented pots, and one (71 mm) was from a vented pot.

Escapement from pots for some species, depending on pot design and construction, has been found to be significant. High and Worlund² found an escapement rate of 80-92 percent for the king crab, *Paralithodes camtschatica*, from pots. High (1976) also found vents increased the rate of escapement for Dungeness crabs, *Cancer magister*, from 21 percent in 74 days in nonvented pots to 45 percent in only 12 days for vented pots. Our known escapement from intact pots was 1 percent. The portion of our missing lobsters (135) that may have been escapees is a matter of speculation, although we believe the degree of escapement from our pots was low.

Damage. Damage, as analyzed in this study, is classified as a major injury, defined as the loss of a cheliped or a crush wound on the thorax or abdomen. These types of wounds were easily recognized by divers and their time of occurrence was placed subsequent to the previous inventory. Minor injuries (regenerate chelipeds, missing walking legs, damaged uropods, etc.) may have escaped immediate detection. All

Table 11.—Summation of mortality, damage, and missing lobsters for ghost pots of study Phases I and II, vented and nonvented pots combined. The numbers and percents given by cumulative 15-day intervals represent an estimate of mortality, damage, and missing lobsters as a function of ghost pot fishing time.

Maximum no. of days trapped	Mortalities No. (%)	Major injuries No. (%)	Missing No. (%)
Phase I			
0- 15	4(6)	4(6)	1(2)
0- 30	5(8)	5(8)	5(8)
0- 45	7(11)	5(8)	6(10)
0- 60	7(11)	6(10)	6(10)
0- 75	7(11)	6(10)	7(11)
0- 90	8(13)	9(14)	7(11)
0-105	8(13)	10(16)	7(11)
0-111	8(13)	10(16)	7(11)
Phase II			
0- 15	8(6)	6(4)	15(10)
0- 30	18(13)	21(15)	26(18)
0- 45	24(17)	23(16)	35(24)
0- 60	25(17)	24(17)	39(27)
0- 75	30(21)	26(18)	45(31)
0- 90	32(22)	30(21)	47(33)
0- 97	32(22)	30(21)	47(33)

Table 12.—Summation of mortality, damage, and missing lobsters for ghost pots of study Phase III, vented and nonvented pots. The numbers and percents given by cumulative 15-day intervals represent an estimate of mortality, damage, and missing lobsters as a function of ghost pot fishing time.

Maximum no. of days trapped	Mortalities No. (%)	Major injuries No. (%)	Missing No. (%)
Phase III—vented traps			
0-15	2(2)	6(7)	16(18)
0-30	6(7)	11(13)	23(26)
0-45	8(9)	14(16)	28(32)
0-60	8(9)	14(16)	29(33)
0-75	8(9)	14(16)	29(33)
0-79	8(9)	14(16)	29(33)
Phase III—nonvented traps			
0-15	15(9)	9(6)	17(10)
0-30	22(14)	33(20)	32(20)
0-45	37(23)	40(25)	42(26)
0-60	53(33)	42(26)	46(28)
0-75	61(38)	47(29)	49(30)
0-79	64(40)	47(29)	52(32)

major and minor damage with date first observed is recorded in Appendix B.

During Phase I there were 10 instances of major damage over a 111-day period; 30 in Phase II over 97 days; 14 from Phase III vented pots and 47 from nonvented pots over 79 days (Tables 11 and 12). Percentage of major injuries from vented and nonvented pot catches was similar within Phases I and II, thus these data were combined. During Phases I and II, 10 and 18 percent of the catch was damaged, compared with 29 percent for Phase III nonvented and 16 percent for vented pot catches over a common time interval of 75 days. In addition to the vented ghost pots having a smaller catch than non-

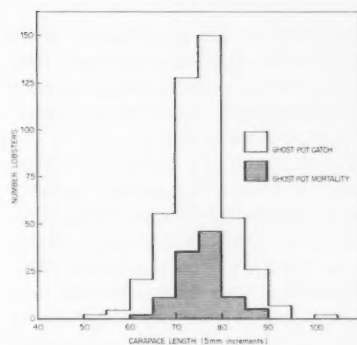


Figure 18.—Length frequency, by 5-mm increments, of all ghost-pot lobsters and all ghost-pot mortalities.

vented in Phase III, the vented pots also had a catch with a reduced rate of damage.

During the entire three phases of the study, we recorded 101 instances of major damage in ghost pots. Twenty-five percent of all major damage occurred within the first 15 days a lobster was entrapped, and 69 percent occurred within the first 30 days. Thirty percent of all lobster mortalities were noted as having major injuries prior to their death. We often noted during diving inventories that a lobster suffering a major injury was subsequently attacked by other entrapped lobsters (either as a source of food or because of their aggressive behavior), often resulting in the loss of chelipeds and walking legs before death.

Mortalities. During the three phases of this study, 112 ghost-pot lobsters were found dead (24.6 percent of total catch) and recorded as ghost-pot mortalities (Table 10). The sizes of lobsters dying in ghost pots were representative of the sizes entrapped (Fig. 18). Mean carapace length of all ghost-pot inhabitants was 75.2 mm compared with 76.1 mm for ghost-pot mortalities. Mortality among males may be greater than for females, although this difference is not significant ($\chi^2_{(df=1)}=1.32$, $P>0.10$). Males composed 60.5 percent ($N=276$) of all ghost-pot catches, females 39.5 percent ($N=180$). Confirmed mortalities were 67 percent

²High, W. L., and D. D. Worlund. 1976. Escape of king crabs from pots. Unpubl. manuscript on file at the Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, 2725 Montlake Boulevard East, Seattle, WA 98112.

($N=75$) males and 33 percent ($N=37$) females. We conclude, therefore, that lobster mortality within the ghost pots is not selective by size or sex, compared with the ghost-pot catch.

Lobster mortality within the ghost pots of Phases I and II did not suggest a density-dependent relationship; catches totalled by pot type and study phase varied from 29 (Phase I, nonvented) to 90 (Phase II, nonvented). Within this catch range, average mortality ranged from 9 to 22 percent, with no apparent association with size of catch. In Phase III, nonvented pots totalled 162 lobsters with 40 percent mortality, compared with vented pot catches totalling 87 lobsters with 9.5 percent mortality. The relatively high catch from the nonvented pots with 40 percent mortality may suggest a density-dependent relationship over the entire catch range of 29 to 162 lobsters, but the data presented herein are insufficient to demonstrate this.

Lobster mortality within ghost pots may be related to water temperature, but the variation in mortality by study phase and pot type is too great to demonstrate such a relationship. Approximate mean water temperatures for Phases I, II, and III were 3-4°C, 10-11°C, and 15-16°C; mortalities for these periods were 17 and 19 percent, 22 and 22 percent, and 40 and 10 percent, respectively, for nonvented and vented pot catches.

Loss Rates. In this section we discuss our findings on ghost-pot lobster mortality, missing individuals, and damage as a function of the time a lobster is retained within the pot. The time of entrapment is summarized cumulatively by 15-day intervals for assessment. Data from Phase I (winter) and Phase II (summer) are compared for an indication of seasonal effects on ghost-pot catch. Phase III data are divided into vented and nonvented pots for a measure of the effectiveness of vents on ghost-pot lobsters.

Summations of mortality, damage, and missing lobsters are presented in Table 11 for Phases I and II. Pots fished in summer caught more lobsters than in the wintertime (Table 9). Phase II

lobsters suffered a 22 percent mortality in 3 months, compared with 13 percent for Phase I, considering only the known deaths. The magnitude of injury was greater in Phase II (21 percent) than Phase I (14 percent) over 3 months. Missing lobsters in Phase II represented 33 percent of the catch compared with 11 percent in Phase I. (These differences, discussed above, may be related to water temperature and are attributed to seasonal influence by us. Moulting occurs during the summer and was probably one reason for the higher summer mortality.)

Summations of ghost-pot lobster mortality, missing lobsters, and lobster injury for Phase III vented and nonvented pots are presented in Table 12. Lobsters from vented pots suffered a 9 percent mortality in 79 days compared with 40 percent in nonvented pots. Sixteen percent of the vented-pot lobsters had injuries compared with 29 percent of the lobsters from nonvented pots. Both pot types demonstrated similar percentages of missing lobsters (32 and 33 percent). We conclude from these comparisons that escape vents resulted in significantly reduced mortality and injury, and similar rates of missing individuals, under the ghost-pot conditions described above for study Phase III.

Table 13.—Macrofauna observed in ghost pots by study phase (I, II, III) and trap type (vented, nonvented).

Species	I		II		III	
	Vented	Non-vented	Vented	Non-vented	Vented	Non-vented
Starfish (<i>Asterias</i> sp.)	+	+	+	+	+	+
Sea urchins (<i>Strongylocentrotus droebachiensis</i>)	+	+	+	+	+	+
Sand dollars (<i>Echinarachnius parma</i>)	1	0	0	0	0	0
Whelks (<i>Neptuna despecta tornata</i>)	+	+	+	+	+	+
(<i>Buccinum undatum</i>)						
(<i>Busycan caricum</i>)						
Cancer crabs (<i>Cancer borealis</i> , <i>C. irroratus</i>)	+	+	+	+	0	0
Spider crabs (<i>Libinia</i> sp., <i>Lithodes maia</i>)	1	1	0	0	0	0
Hermit crabs (<i>Paragarus</i> sp.)	+	+	+	+	+	+
Sea raven (<i>Hemipteraster americanus</i>)	0	2	0	1	0	0
Sculpin (<i>Myoxocephalus</i> sp.)	0	1	0	1	0	0
Eel pout (<i>Lycodes reticulatus</i>)	0	1	0	1	0	0
Cod (<i>Gadus callarias</i>)	2	0	0	0	0	0
Black sea bass (<i>Centropristis striata</i>)	0	0	0	0	5	11
Cunner (<i>Tautoglabrus adspersus</i>)	0	0	0	0	0	1
Scup (<i>Stenotomus versicolor</i>)	0	0	0	0	0	0
Sea robin (<i>Prionotus carolinus</i>)	0	0	0	0	0	0

1+ = species were present but were not assessed due to 1) large concentration and/or 2) poor visibility for visual assessment.

Macrofaunal Catches. Macrofauna found in surface-hauled pots and ghost pots were recorded for an indication of pot attraction for species other than lobsters and their interactions with lobsters. A listing of macrofauna by study phase and pot type is presented in Table 13 for ghost pots and Table 14 for surface-hauled pots.

During Phases I and II, cancer crabs *Cancer irroratus* and *C. borealis*, were the most abundant macrofauna taken from the surface-hauled and ghost pots. Counts of cancer crabs and other invertebrates were not made from ghost pots because of the limited dive time at depth for the scuba team. Spider crabs (*Libinia* sp.) and whelks, *Neptuna despecta tornata* and *Busycan caricum*, were the most common macrofauna taken from surface-hauled and ghost pots from Phase III. Occasional catches of finfish were made with all pot types, with the sea raven, *Hemipteraster americanus*, sculpin (*Myoxocephalus* sp.), cod, *Gadus callarias*, black sea bass, *Centropristis striata*, and scup, *Stenotomus chrysops*, being the most common.

A relationship between cancer crabs and lobsters in ghost pots during Phases I and II was noted. The apparently desirable niches for both species in our ghost-pot's parlors were the four cor-

Table 14.—Macrofauna observed in surface hauled pots by study phase (I, II, III) and pot type (vented, nonvented).

Species	I		II		III	
	Vented	Non-vented	Vented	Non-vented	Vented	Non-vented
Starfish (<i>Asterias</i> sp.)	0	10	0	0	0	2
Sea urchins (<i>Strongylocentrotus droebrachiensis</i>)	0	165	0	2	0	0
Sand dollars (<i>Echinarachnius parma</i>)	0	150	1	0	0	0
Whelks (<i>Neptuna despecta tornata</i>)	0	0	0	0	8	94
(<i>Buccinum undatum</i>)						
(<i>Busycon caricum</i>)						
Cancer crabs (<i>Cancer borealis</i> , <i>C. irroratus</i>)	230	458	94	425	0	1
Spider crabs (<i>Lubinia</i> sp., <i>Lithodes maia</i>)	1	3	0	0	17	288
Hermit crabs (<i>Paragurus</i> sp.)	4	2	1	0	0	0
Sea raven (<i>Hemirhamphus americanus</i>)	2	1	0	0	0	0
Sculpin (<i>Myoxocephalus</i> sp.)	3	0	0	4	0	0
Eel pout (<i>Lycodes reticulatus</i>)	1	0	0	1	0	0
Cod (<i>Gadus callarias</i>)	0	0	2	5	0	0
Black sea bass (<i>Centropristis striata</i>)	0	0	0	0	0	0
Cunner (<i>Tautoglabrus adspersus</i>)	0	0	2	0	1	0
Scup (<i>Stenotomus versicolor</i>)	0	0	0	0	1	8
Sea robin (<i>Prionotus carolinus</i>)	0	0	0	0	1	0

ners and a location under the parlor head. If only lobsters were present in a pot, these niches were occupied by them. If there were lobsters and crabs in a pot, the desired niches were always occupied by crabs. Our observations in tanks with a combination of lobsters and crabs also confirms the apparent dominance crabs have over lobsters in occupying a niche desirable to both species. This establishment of a dominance for niches seems to result in no physical injury during the original encounters of the two species for desired areas.

Three ghost pots in Phase III had extensive lobster mortality after black sea bass, *Centropristis striata*, had been observed in the pot parlors. In trap 72, on the inventory day that two black sea bass were found in the pot, there were eight dead lobsters (from a total of 13); on the next inventory, after immigration of new lobsters, there were nine additional mortalities; and on the next inventory, with one bass still trapped, three additional lobster mortalities were recorded. At this point, only one lobster was left alive and this individual had all legs missing. For the time-span that these bass were trapped (26 June-2 August), 20 lobsters had died. Similar circumstances occurred during the same dates (26 June-2 August) in two other

ghost pots. In pot 77, bass were found along with 13 dead lobsters, and in pot 78, bass were found along with 11 dead lobsters.

The high lobster mortality coincident with the entrapment of black sea bass in these three pots and not a correspondingly high mortality in the other pots during the same time suggests that the bass, either directly or indirectly, were the cause of the increased mortality; or possibly, the bass entered coincidentally with a general rise in water temperature or some other factor that caused the mortalities.

New lobsters did not avoid the three pots with bass. Into each of the three pots with black sea bass, lobsters continued to enter, in the presence of fish and dead lobsters. Morgan (1974) found that western rock lobsters tended to avoid pots with dead lobsters or a predator; this was apparently not true with us. Our three pots had a high initial, and continuing, mortality for as long as the bass remained trapped. These sea bass had the most damaging effect of macrofauna recorded during this study.

Environmental Measurements. For a normal range of temperatures, McLeese and Wilder (1958) found American lobster catchability to in-

crease with temperature. Morgan (1974) found a positive correlation between water temperature and catchability, and between salinity and catchability, of the western rock lobster, *Panulirus cygnus*. Lofts (1956) also found a positive correlation between salinity and the metabolic rate of some decapod crustaceans.

A general increase in lobster catch with increasing water temperatures was found during this study. During Phases I and II in Maine, seawater temperatures were 1.0°C in February and gradually rose to the 13-14°C range at the conclusion of Phase II (Fig. 19). Readings of salinity in parts per thousand ranged from 31.8 to 29.1, dissolved oxygen ranged between 8.3 and 12.0 parts per million, and pH ranged from 8.25 to 8.86 (Table 15).

The Phase III environmental data was limited to daily temperatures at the laboratory dockside approximately 5 miles from the Weepecket Islands. Although dockside temperatures would not give an accurate portrait of the actual study area temperatures, they would reflect general temperature trends in the area. During Phase III, the Woods Hole ocean temperature trends gradually rose from approximately 12°C in May to about 20-22°C at the end of the study.

We found no correlation between salinity and catch, although this type of relationship in the natural environment may be caused by the resulting surge activity from wind and rain storms having a dampening effect on lobster activity in shallow-water areas.

Trap-Head Design. To replace damaged traps, new traps were constructed for Phase III. Each of the eight strings consisted of four old traps and one new trap. The new traps were constructed by a local lobsterman who was given an old trap and told to make the new one identical to it.

Upon receipt, the new traps seemed identical, and only upon close examination was a variation in inner-head design noticed. The difference, as shown in Figures 20-21, was that the new heads were one mesh less in circumference. The net result can be seen in the

illustration: a shorter, steeper head, with a larger "skate-mouth" opening.

The new traps caught significantly fewer lobsters ("ghost" traps #61, 66, 71, and 76; "fished" traps #41, 46, 51, and 56). By reviewing the ghost-trap catch data it seems that the deficiency of the new trap was that it did not retain lobsters caught. Observations in laboratory aquarium tanks confirmed this.

SUMMARY

1) This report has presented the results of an in situ study on lobster behavior, mortality, and immigration-emigration regarding commercial pot gear fished in conventional (surface-hauled) and "ghost-pot" modes in the Boothbay region of Maine, and Woods Hole, Mass. Four experimental (ghost-pot) and four control (surface-

hauled) trawls of five pots per trawl were fished at similar depths and in similar lobster habitats at 1-week intervals. The conventional trawls were hauled and examined at the surface, and ghost-pot trawls were examined at depth by divers during the daytime.

2) Sublegal escape vents and biodegradable panels were constructed in pots, according to a specified sampling design, for each of the experimental

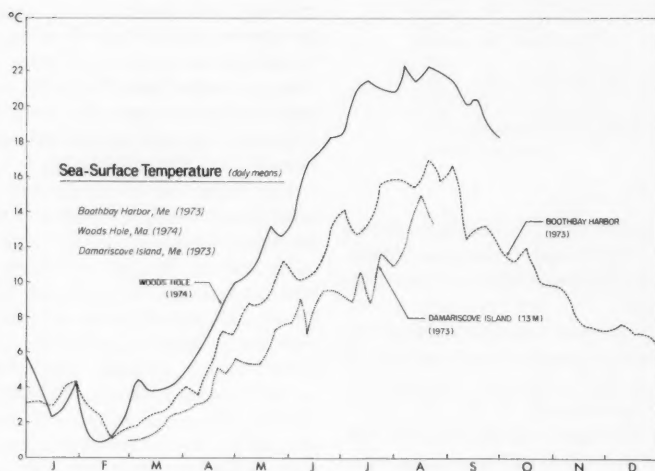


Figure 19.—Temperatures of 40 foot depth, Damariscove Island, Maine; Woods Hole Laboratory dock 4 feet below mean low surface.

Table 15.—Temperature, pH, salinity, and dissolved O₂ at study site during Phases I and II.

Date	Temp. (°C)	pH	Salinity (ppt)	O ₂ (ppm)
2/27	1.0	8.78	31.8	11.8
3/13	1.4	8.66	31.4	11.5
3/21	2.2	8.35	31.4	10.4
3/29	2.5	8.70	30.6	11.0
4/5	3.0	8.34	30.4	10.8
4/13	3.1	8.54	31.5	10.8
4/18	3.6	8.68	31.5	10.8
4/20	5.0	8.62	30.9	12.0
4/24	4.8	8.25	30.8	10.6
5/1	5.6	8.68	30.0	10.0
5/7	5.4	8.38	29.8	9.6
5/14	5.4	8.43	30.2	10.0
5/24	7.2	8.81	30.0	10.5
6/1	7.7	8.72	29.9	9.8
6/4	9.0	8.84	29.1	10.0
6/11	7.0	8.74	—	10.0
6/18	9.5	8.82	29.7	9.0
6/28	9.5	8.86	30.1	10.8
7/6	9.0	8.65	30.3	10.8
7/10	10.4	8.52	29.9	9.8
7/16	8.8	8.76	30.8	8.3
7/23	11.5	8.48	30.1	10.0
7/31	10.8	—	30.4	8.8
8/6	12.3	—	30.6	8.9
8/17	14.8	—	30.6	9.2
8/21	13.5	—	31.0	8.8

Figure 20.—Inner head construction—"old" trap.

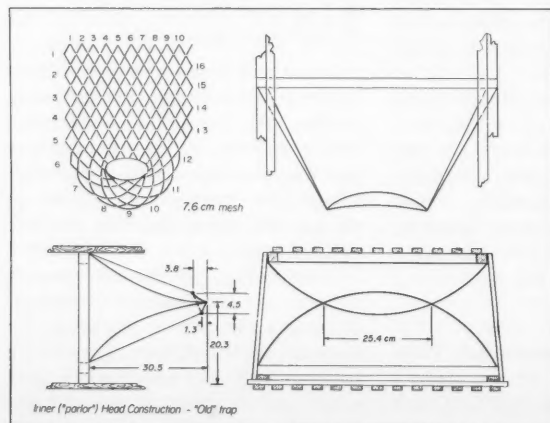
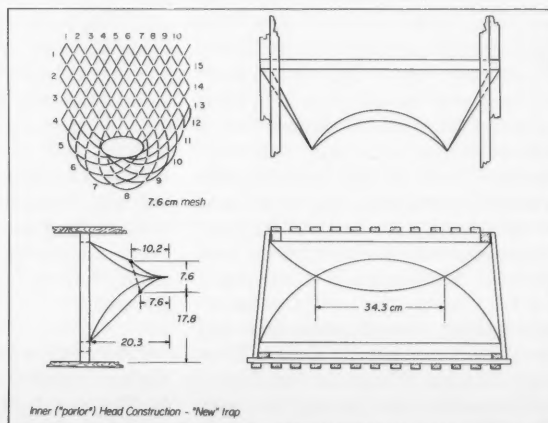


Figure 21.—Inner head construction—"new" trap.



and control trawls. Observations on behavior, mortality, and immigration-emigration were related to the presence or absence of escape vents and panels. In study Phases I and II, vented pots had lath spacings of 38-43 mm, and non-vented pots 25-33 mm. In study Phase III, vented pots had a standardized vent opening of 45 mm, compared with the 25- to 33-mm spacing of the control pots.

3) Newly entrapped lobsters from the ghost pots were given color-coded tags (primary mark), thus subsequent sightings and identification did not require repeated handling of the tagged individual. Each tagged lobster was given a secondary mark; a 3- to 4-mm hole was punched into one of the five tail fan sections to identify experimental lobsters through at least one moult. Disturbance to the occupants of the ghost pot was minimal.

4) Night dives were made on several occasions during study Phases I and II off the coast of Maine. Lobsters leaving their shelters at night, termed nocturnally active, were sampled by the divers to define the size distribution and sex ratio of the population from which the control (conventional) and experimental (ghost-pot) catches were derived. The behavior of lobsters and other fauna within the ghost pots was observed during these dives to compare with similar observations made during the daytime. Surrounding lobster habitats were searched for marked individuals that had escaped the ghost pots. Comparable observations at night were not possible during study Phase III because of poor underwater visibility.

5) Of the 448 nocturnally active lobsters collected from the Boothbay, Maine, study area, the sex ratio did not differ significantly from 50:50; mean carapace length, similar for males and females, was 70 mm. Nocturnally active individuals ranged from 45 to 91 mm.

6) Surface-haled pots caught 3,425 lobsters over 53 sampling periods for study Phases I, II, and III. Mean carapace lengths by pot type (vented VS nonvented) and study phase were similar. Vented pots caught fewer

lobsters (83, 81, and 37 percent for Phases I, II, and III) and larger lobsters ($C.L._{vented} = 76.3, 78.1, \text{ and } 78.8 \text{ mm}$; $C.L._{nonvented} = 74.6, 76.1, \text{ and } 74.0 \text{ mm}$) than nonvented pots.

7) Twenty-eight percent of the lobsters taken by the surface-hauled pots had one or more types of body damage; the most common injuries were damaged, regenerate, or missing claws. Incidence of damage, judged new or old, was similar for vented and nonvented pots.

8) Sex ratios of the diver-collected nocturnally active lobsters and the surface-hauled pot catches were similar. Surface-hauled catches yielded larger lobsters than diver-collected samples; pot catches averaged 75- to 79-mm carapace length compared with 70 mm for diver collections. Pots rarely caught lobsters less than 60 mm whereas divers collected nocturnally active lobsters as small as 45 mm. We believe the 45- to 60-mm lobsters entered the surface-hauled pots but were not retained because of the lath spacing and escape vents.

9) Mean sizes of male and female lobsters by ghost-pot type are similar: mean sizes of lobsters (sexes combined) from vented and nonvented pots are similar for study Phases I and II, thus these data are combined giving an overall mean carapace length of 74.8 mm (Phase I) and 72.5 mm (Phase II). We believe this similarity is due to: 1) relatively small differences in lath spacing between conventional (nonvented, 25-33 mm) and experimental (vented, 38-43 mm) pots, and 2) comparatively small numbers of lobsters captured by the ghost pots. For study Phase III, vented pots (45-mm vent) captured lobsters of a larger average size than nonvented pots (78.3 mm VS 76.0 mm, sexes combined). Here the greater differential in lath spacing permitted a greater degree of escape of larger lobsters from the vented pots.

10) Sex ratios for vented and nonvented ghost-pot catches for Phases I and II approximated 50:50. Males predominated the vented (61 percent) and nonvented (64 percent) pot catches in Phase III.

11) Ghost pots of study Phases I, II, and III retained 456 lobsters that were recorded during weekly diving inventories. Captures during Phase I totaled 63 lobsters, 47 entering the pots while bait remained and 16 thereafter. Phase II totaled 144; 79 entered while bait remained and 65 thereafter. Phase III had 249 lobsters with 125 entering while pots were baited and 124 thereafter. A history of each lobster captured by a ghost pot is presented.

12) Ghost pots selectively captured large lobsters ($C.L.$ for Phases I and II ranged from 73.4 to 78.3 mm, depending on pot type) but were not selective by sex, with the exception of Phase III. Here, males predominated (64 percent) in both the nonvented catches, compared with the assumed percentage (50 percent) of nocturnally active males (derived from the surface pot catches) and vented pot catches (61 percent compared with 44 percent from the surface vented pot catches). Diver collections of the nocturnally active portion of the population were not possible during study Phase III.

13) We have defined two classes of escapees from ghost pots: 1) lobster escaping the pot through an opening created by the erosion of a degradable linked panel or a pot structure failure, and 2) lobster escaping from an intact pot and later recaptured by pots or divers. A total of 46 lobsters escaped through degradable panels that had opened during Phases I, II, and III. Of the lobsters classified as missing from intact pots, eight were recaptured. The portion of lobsters classified as missing that may have been escapees is believed to be low.

14) Damage, or major injury, is defined in this study as characterizing a lobster whose cheliped(s) are missing, and/or whose abdomen or thorax has a "crushing" type of wound. During study Phases I, II, and III there were 19 (16 percent), 30 (21 percent), and 61 (14 [16] vented, 47 [30 percent] nonvented) instances of major damage of ghost-pot lobsters over time intervals ranging up to 79-111 days. Vented pots from Phase III had a catch with a reduced rate of damage compared with

the catch from nonvented pots. Rates of damage from vented and nonvented pots in Phases I and II were similar; again, catch rates for these pots were similar, as noted above. Twenty-five percent of all major damage occurred within the first 15 days of ghost-pot entrapment, and 69 percent within the first 30 days. Thirty percent of all lobster mortalities had major injuries prior to their death.

15) During the three phases of the study, 112 (25 percent) were found dead in ghost pots. Lobster mortality was not selective by size or sex, compared with the ghost-pot catch; mean carapace length for all ghost-pot inhabitants was 75.2 mm, and 76.1 mm for ghost-pot mortalities. Males composed 60.5 percent of all ghost-pot catches, compared with 67.0 percent male mortality. Lobster mortality does not appear to be density-dependent.

CONCLUSIONS

1) Selectivity of traps can be improved by the use of sublegal escape vents.

2) Reducing the overall catch of a trap, by permitting escapement of sublegal lobsters, reduces injuries and mortality induced by entrapment.

3) Incidence of trap-related injury and mortality is probably a function of one, or a combination of: 1) water temperature, 2) fishing pressure, 3) trap set-over days, and 4) physical condition of the lobster, i.e., its nearness to moult.

4) Ghost traps continue to fish for extended periods of time, having a catch rate equal to approximately 10 percent of the surface-hauled traps. Twenty-five percent of the ghost-pot lobsters died.

5) Vented traps with a 45-mm lath spacing had significantly fewer mortalities during the ghost-fishing period than nonvented traps with 25- to 33-mm spacings. Traps with lath spacings less than 45 mm have lobster mortalities similar to the conventional nonvented traps.

6) Trap-mounted escape panels are an effective means of releasing entrapped lobsters.

7) The percentage of missing lobsters from vented and nonvented pots was similar.

8) Lobster catch, mortality, and damage were greater in summer than in winter.

9) Lobsters dying in ghost pots were representative of the trappable population in terms of size and sex ratio.

10) Major trap-related mortalities may be caused by factors other than interspecific actions, e.g., agitation by other entrapped macrofauna such as cancer crabs, black sea bass, etc.

11) Lobsters moulting within a trap with other lobsters present are generally cannibalized.

12) The major portion of damage and mortality among entrapped lobsters occurs during the first 30 days of confinement.

13) Lobsters and finfish enter unbaited traps, perhaps seeking shelter, and their trap deaths may act as a baiting process.

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APPENDIX A

Field Experiment Catch Data

Key to listings

- DATE: Year, month, day
 SOD: Set over days
 T#: Trap number
 V: Vented
 S: Sex, male or female
 LEN: Carapace length (mm)
 WID: Carapace width (mm)
 H: Indicates either left (L) or right (R) crusher claw
 E: Egg condition: 1 = new eggs (black); 2 = ripe eggs (red); 3 = eggs recently released
 D: Damage code (1 indicates no damage)

LOBSTER DATA - SURFACE HAULED TRAPS
BOOTHBAY HARBOR, MAINE 1973

DATE	SBD	T#	V	S	LEN	WID	H	E	D
730205	10	04	V	F	074	R	L	1	
730205	10	04	V	M	078	R	L	1	
730205	10	05	V	F	079	R	L	1	
730205	10	05	V	M	087	R	L	1	
730205	10	06	V	M	079	R	L	1	
730205	10	07	V	M	076	R	L	1	
730205	10	08	V	F	072	R	L	1	
730205	10	08	V	F	073	R	L	1	
730205	10	10	V	F	077	R	L	1	
730205	10	10	V	F	068	R	L	1	
730205	10	10	V	M	077	R	L	1	
730205	10	11	M	067	R	L	1		
730205	10	11	F	073	R	L	1		
730205	10	11	M	081	R	L	1		
730205	10	11	M	073	R	L	1		
730205	10	11	F	071	R	L	1		
730205	10	12	F	082	R	L	1		
730205	10	13	F	072	R	L	1		
730205	10	13	M	081	R	L	1		
730205	10	13	M	071	R	L	1		
730205	10	13	M	070	R	L	1		
730205	10	13	M	066	R	L	1		
730205	10	13	F	078	R	L	1		
730205	10	14	M	076	R	L	1		
730205	10	14	F	077	R	L	1		
730205	10	14	M	077	R	L	1		
730205	10	14	F	093	R	L	1		
730205	10	14	M	072	R	L	1		
730205	10	14	F	076	R	L	1		
730205	10	14	F	069	R	L	1		
730205	10	15	F	087	R	L	1		
730205	10	15	F	075	R	L	1		
730205	10	15	F	079	R	L	1		
730205	10	15	M	072	R	L	1		
730205	10	15	F	070	R	L	1		
730205	10	15	M	081	R	L	1		
730205	10	15	M	071	R	L	1		
730205	10	15	F	072	R	L	1		
730205	10	16	M	078	R	L	1		
730214	09	01	V	F	079	R	L	1	
730214	09	02	V	F	069	R	L	1	
730214	09	04	V	M	074	R	L	1	
730214	09	05	V	F	070	R	L	1	
730214	09	08	V	F	078	R	L	1	
730214	09	09	V	M	074	R	L	1	
730214	09	11	V	M	071	R	L	1	
730214	09	31	M	069	R	L	1		
730214	09	32	M	079	R	L	1		
730214	09	32	M	070	R	L	1		
730214	09	32	F	082	R	L	1		
730214	09	32	F	076	R	L	1		

DATE SBD T# V S LEN WID H E D

730126	01	V	M	077	L	L	1		
730126	01	V	F	087	L	L	1		
730126	01	V	F	058	R	L	1		
730126	01	V	M	083	R	L	1		
730126	01	V	F	078	R	L	1		
730126	01	V	F	074	R	L	1		
730126	02	V	F	070	R	L	1		
730126	02	V	M	077	L	L	1		
730126	02	V	M	075	L	L	1		
730126	02	V	M	081	R	L	1		
730126	02	V	F	072	R	L	1		
730126	02	V	M	070	R	L	1		
730126	03	V	F	082	L	L	1		
730126	03	V	F	072	L	L	1		
730126	03	V	M	080	L	L	1		
730126	03	V	M	081	L	L	1		
730126	03	V	M	076	R	L	1		
730126	04	V	M	091	R	L	1		
730126	04	V	M	073	R	L	1		
730126	04	V	M	083	R	L	1		
730126	04	V	M	081	R	L	1		
730126	04	V	M	076	R	L	1		
730126	04	V	F	075	R	L	1		
730126	04	V	F	071	L	L	1		
730126	05	V	M	075	L	L	1		
730126	05	V	M	076	R	L	1		
730126	05	V	M	066	R	L	1		
730126	05	V	M	073	R	L	1		
730126	05	V	F	066	R	L	1		
730126	06	V	F	080	R	L	1		
730126	06	V	M	074	R	L	1		
730126	06	V	F	073	L	L	1		
730126	06	V	M	081	R	L	1		
730126	06	V	M	076	R	L	1		
730126	06	V	F	069	R	L	1		
730126	07	V	M	082	L	L	1		
730126	07	V	M	080	L	L	1		
730126	07	V	M	076	R	L	1		
730126	08	V	M	079	R	L	1		
730126	08	V	F	077	R	L	1		
730126	08	V	M	078	L	L	1		
730126	08	V	F	074	L	L	1		
730126	08	V	F	076	L	L	1		
730126	08	V	F	080	L	L	1		
730126	09	V	F	080	R	L	1		
730126	31	F	078	R	L	1			
730126	32	M	084	L	L	1			
730126	33	F	071	L	L	1			
730126	33	F	080	R	L	1			

DATE SBD T# V S LEN WID H E D

730126	33	F	068	L	L	1			
730126	34	M	079	R	L	1			
730126	34	M	095	R	L	1			
730126	34	M	080	R	L	1			
730126	34	M	075	R	L	1			
730126	34	M	076	R	L	1			
730126	35	F	081	L	L	1			
730126	35	F	070	L	L	1			
730126	35	M	080	L	L	1			
730126	35	F	078	L	L	1			
730126	35	F	077	L	L	1			
730126	35	F	086	L	L	1			
730126	35	M	070	R	L	1			
730126	35	M	074	R	L	1			
730126	36	M	074	L	L	1			
730126	36	M	088	L	L	1			
730126	36	F	073	R	L	1			
730126	36	F	070	R	L	1			
730126	36	F	080	L	L	1			
730126	36	M	080	L	L	1			
730126	37	F	080	R	L	1			
730126	37	F	076	R	L	1			
730126	37	M	077	L	L	1			
730126	37	M	077	L	L	1			
730126	38	F	072	R	L	1			
730126	38	F	070	R	L	1			
730126	38	M	068	L	L	1			
730126	38	M	073	R	L	1			
730126	38	F	083	R	L	1			
730126	39	F	076	L	L	1			
730126	39	M	087	R	L	1			
730126	39	F	080	R	L	1			
730126	40	F	075	L	L	1			
730126	40	M	075	R	L	1			
730126	40	M	074	R	L	1			
730126	40	M	075	L	L	1			
730126	40	M	073	L	L	1			
730126	40	M	078	L	L	1			
730126	40	F	070	R	L	1			
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730205	10	01	V	F	070	R	L	1	
730205	10	01	V	F	071	R	L	1	
730205	10	01	V	F	073	R	L	1	
730205	10	02	V	F	071	R	L	1	
730205	10	03	V	M	076	R	L	1	
730205	10	03	V	F	077	R	L	1	
730205	10	03	V	F	077	R	L	1	
730205	10	04	V	M	075	R	L	1	

LOBSTER DATA - SURFACE HAULED TRAPS
BOOTHBAY HARBOR, MAINE 1973

BOSTON HARBOUR, MAINE 1973									
DATE	SBD	T#	V	S	LEN	WID	H	E	D
730214	09	33	M	078		R	L	1	
730214	09	33	M	087		R	L	1	
730214	09	33	F	074		L	L	1	
730214	09	33	F	067		L	L	1	
730214	09	34	M	079		R	L	1	
730214	09	34	M	066		R	R	L	1
730214	09	34	F	070		R	L	1	
730214	09	35	M	078		R	L	1	
730214	09	37	M	069		R	L	1	
730220	06	31	F	077		R	L	1	
730220	06	31	F	063		L	R	1	
730220	06	31	F	075		R	L	1	
730220	06	31	M	074		R	L	1	
730220	06	32	M	079		R	L	1	
730220	06	32	F	063		R	L	1	
730220	06	32	F	079		R	L	1	
730220	06	32	F	087		R	L	1	
730220	06	33	F	085		R	L	1	
730220	06	33	F	088		L	L	1	
730220	06	33	M	072		L	L	1	
730220	06	34	M	084		R	L	1	
730220	06	34	M	088		L	L	1	
730226	06	06	V	M	072		L	L	1
730226	06	10	V	M	074		R	L	1
730226	06	33	F	064		R	L	1	
730226	06	33	F	064		R	L	1	
730226	06	34	F	074		R	L	1	
730226	06	34	F	078		R	L	1	
730226	06	34	M	082		R	L	1	
730226	06	35	F	082		R	L	1	
730226	06	37	F	067		R	L	1	
730309	10	05	V	F	049		R	L	1
730309	10	08	V	M	068		R	L	1
730309	10	09	V	F	083		R	L	1
730309	10	09	V	M	080		R	L	1
730309	10	10	V	M	080		R	L	1
730315	06	31	F	075		L	R	1	
730315	06	35	F	081		L	R	1	
730380	05	01	V	M	078				
730380	05	07	V	M	085				
730380	05	08	V	M	065		R	L	1
730380	05	09	V	M	071		R	L	1
730380	05	09	V	F	077		R	L	1
730380	05	10	V	M	076		R	L	1
730380	05	10	V	M	082		R	L	1
730380	05	10	V	M	071		R	L	1
730380	05	31	F	075		R	L	1	
730380	05	32	M	071		R	L	1	
730380	05	33	F	077		R	L	1	
730380	05	34	F	082		R	L	1	

LOBSTER DATA - SURFACE HAULED TRAPS
BOOTHBAY HARBOR, MAINE 1973

DATE SBD T# V S LEN WID H E D

730413	10 40	F 066	L	1
730413	10 40	F 076	L	1
730413	10 40	F 081	L	1
730413	10 40	F 080	R	1
730413	10 40	M 075	L	1
730418	05 01	V F 072	L	1
730418	05 02	V F 077	L	1
730418	05 02	V F 077	L	1
730418	05 05	V M 072	L	1
730418	05 05	V F 072	L	1
730418	05 05	V M 071	L	1
730418	05 05	V M 070	L	1
730418	05 05	V F 075	L	1
730418	05 06	V F 078	L	1
730418	05 06	V M 080	R	1
730418	05 06	V F 076	L	1
730418	05 08	V M 078	R	1
730418	05 08	V F 073	R	1
730418	05 08	V F 081	L	1
730418	05 09	V F 078	L	1
730418	05 09	V F 081	L	1
730418	05 09	V M 073	R	1
730418	05 09	V M 073	R	1
730418	05 31	M 077	R	1
730418	05 31	F 087	R	1
730418	05 31	F 086	R	1
730418	05 32	M 085	R	1
730418	05 32	F 074	R	1
730418	05 32	F 071	L	1
730418	05 32	F 077	L	1
730418	05 33	M 075	L	1
730418	05 34	F 083	L	1
730418	05 34	M 073	L	1
730418	05 35	F 092	L	1
730418	05 35	M 074	L	1
730418	05 35	M 074	L	1
730424	06 01	V M 066	L	1
730424	06 02	V F 086	L	1
730424	06 02	V F 075	L	1
730424	06 02	V F 071	L	1
730424	06 03	V F 077	R	1
730424	06 03	V F 077	R	1
730424	06 03	V M 077	R	1
730424	06 03	V M 080	R	1
730424	06 04	V M 074	R	1
730424	06 04	V F 079	R	1
730424	06 04	V M 080	L	1
730424	06 04	V F 069	R	1
730424	06 05	V M 081	L	1
730424	06 06	V M 078	R	1

DATE SBD T# V S LEN WID H E D

730424	06 06	V M 081	L	1
730424	06 06	V F 080	L	1
730424	06 07	V M 074	L	1
730424	06 07	V F 077	L	1
730424	06 08	V M 072	R	1
730424	06 08	V F 085	R	1
730424	06 08	V M 077	L	1
730424	06 08	V M 076	L	1
730424	06 09	V M 080	L	1
730424	06 09	V M 079	L	1
730424	06 09	V F 077	L	1
730424	06 09	V F 080	L	1
730424	06 10	V M 075	R	1
730424	06 10	V F 063	L	1
730424	06 10	V M 072	L	1
730424	06 10	V M 074	R	1
730424	06 33	M 066	R	1
730424	06 33	F 070	R	1
730424	06 34	F 076	R	1
730424	06 34	F 063	L	1
730424	06 34	M 080	L	1
730424	06 34	M 079	L	1
730424	06 35	M 078	L	1
730424	06 35	F 062	F	1
730424	06 36	F 066	R	1
730424	06 37	M 071	L	1
730424	06 37	M 065	R	1
730424	06 37	F 077	R	1
730424	06 38	F 079	R	1
730424	06 38	M 074	R	1
730424	06 38	M 085	R	1
730424	06 38	M 082	R	1
730424	06 39	M 080	R	1
730424	06 39	M 070	L	1
730424	06 39	M 077	L	1
730424	06 40	M 079	L	1
730424	06 40	M 076	L	1
730424	06 40	M 080	L	1
730424	06 40	M 077	L	1
730430	06 01	V F 071	R	1
730430	06 01	V M 084	L	1
730430	06 01	V M 072	L	1
730430	06 02	V F 078	L	1
730430	06 02	V F 084	R	1
730430	06 02	V F 090	L	1
730430	06 02	V M 071	R	1
730430	06 02	V F 074	R	1
730430	06 03	V F 077	R	1
730430	06 03	V M 067	R	1
730430	06 04	V M 081	L	1

DATE SBD T# V S LEN WID H E D

730430	06 04	V M 079	R	1
730430	06 04	V F 079	R	1
730430	06 04	V M 076	L	1
730430	06 04	V M 083	R	1
730430	06 06	V M 087	R	1
730430	06 06	V F 076	R	1
730430	06 06	V F 084	R	1
730430	06 06	V M 077	R	1
730430	06 06	V F 077	R	1
730430	06 06	V F 074	R	1
730430	06 07	V M 077	R	1
730430	06 07	V M 076	R	1
730430	06 07	V M 080	L	1
730430	06 07	V M 081	L	1
730430	06 07	V F 107	R	1
730430	06 09	V F 087	R	1
730430	06 09	V M 073	L	1
730430	06 09	V F 085	L	1
730430	06 09	V F 075	R	1
730430	06 09	V F 074	L	1
730430	06 09	V F 078	R	1
730430	06 09	V M 072	R	1
730430	06 09	V M 072	R	1
730430	06 10	V M 082	R	1
730430	06 10	V M 072	R	1
730430	06 31	F 079	L	1
730430	06 31	F 060	R	1
730430	06 31	F 078	R	1
730430	06 31	M 064	L	1
730430	06 31	F 077	L	1
730430	06 31	F 085	L	1
730430	06 31	M 070	L	1
730430	06 33	M 078	R	1
730430	06 33	M 071	L	1
730430	06 33	M 067	L	1
730430	06 34	F 076	R	1
730430	06 34	M 073	L	1
730430	06 34	F 071	L	1
730430	06 34	M 068	L	1
730430	06 34	M 070	L	1
730430	06 35	M 084	L	1
730430	06 35	M 087	L	1
730430	06 36	F 077	R	1
730430	06 36	F 069	L	1
730430	06 36	F 075	R	1
730430	06 36	F 068	L	1
730430	06 37	M 076	L	1
730430	06 37	M 073	L	1
730430	06 37	M 082	L	1
730430	06 37	M 078	R	1
730430	06 38	M 074	H	1

LOBSTER DATA - SURFACE HAULED TRAPS
BOOTHBAY HARBOR, MAINE 1973

DATE SBD T# V S LEN WID H E D

730507	06 38	F 076	L	1
730507	06 38	F 075	R	1
730507	06 38	F 073	L	1
730507	06 39	M 069	R	1
730507	06 39	F 076	R	1
730507	06 39	F 074	L	1
730507	06 39	F 070	L	1
730507	06 39	M 068	L	1
730507	06 39	F 067	R	1
730507	07 01	V F 089	R	1
730507	07 01	V M 079	R	1
730507	07 01	V F 077	R	1
730507	07 01	V M 071	L	1
730507	07 01	V F 074	R	1
730507	07 01	V F 073	L	1
730507	07 02	V F 072	L	1
730507	07 02	V M 074	L	1
730507	07 02	V M 073	L	1
730507	07 02	V F 071	R	1
730507	07 02	V F 079	L	1
730507	07 02	V M 078	R	1
730507	07 02	V M 079	L	1
730507	07 03	V M 072	R	1
730507	07 03	V M 081	R	1
730507	07 03	V F 080	L	1
730507	07 03	V M 077	R	1
730507	07 03	V F 075	L	1
730507	07 03	V F 071	R	1
730507	07 04	V M 070	L	1
730507	07 05	V F 078	R	1
730507	07 05	V M 068	R	1
730507	07 06	V M 080	R	1
730507	07 06	V F 079	R	1
730507	07 06	V M 071	L	1
730507	07 06	V M 075	L	1
730507	07 08	V F 068	L	1
730507	07 08	V F 073	R	1
730507	07 08	V F 078	R	1
730507	07 08	V F 081	L	1
730507	07 09	V F 074	L	1
730507	07 09	V F 077	R	1
730507	07 09	V F 080	R	1
730507	07 09	V F 072	L	1
730507	07 09	V M 075	L	1
730507	07 09	V F 077	R	1
730507	07 09	V M 081	R	1
730507	07 10	V M 059	L	1
730507	07 10	V F 081	R	1
730507	07 10	V M 072	R	1

DATE SBD T# V S LEN WID H E D

730507	07 10	V M 065	L	1
730507	07 31	F 072	L	1
730507	07 31	F 067	R	1
730507	07 31	M 076	R	1
730507	07 31	F 068	L	1
730507	07 31	F 074	L	1
730507	07 31	M 072	L	1
730507	07 31	F 076	R	1
730507	07 31	F 071	R	1
730507	07 32	M 073	R	1
730507	07 32	M 075	R	1
730507	07 32	M 071	L	1
730507	07 32	F 064	L	1
730507	07 32	F 081	R	1
730507	07 32	F 066	L	1
730507	07 32	M 077	R	1
730507	07 32	M 080	L	1
730507	07 33	F 073	L	1
730507	07 33	M 074	R	1
730507	07 33	F 072	L	1
730507	07 33	M 077	R	1
730507	07 33	F 069	L	1
730507	07 33	F 071	R	1
730507	07 33	F 066	R	1
730507	07 34	F 077	R	1
730507	07 34	F 073	R	1
730507	07 34	F 078	R	1
730507	07 34	M 080	R	1
730507	07 34	M 072	R	1
730507	07 34	F 077	R	1
730507	07 34	M 073	R	1
730507	07 34	M 080	L	1
730507	07 34	F 084	L	1
730507	07 35	M 079	R	1
730507	07 36	F 091	L	1
730507	07 36	M 074	L	1
730507	07 36	F 074	L	1
730507	07 37	M 068	R	1
730507	07 37	F 075	R	1
730507	07 37	F 076	R	1
730507	07 37	F 079	R	1
730507	07 37	M 082	L	1
730507	07 37	F 075	R	1
730507	07 37	M 081	L	1
730507	07 37	F 072	R	1
730507	07 37	M 068	L	1
730507	07 38	M 071	R	1
730507	07 38	F 068	R	1
730507	07 38	M 070	R	1
730507	07 38	F 079	L	1

DATE SBD T# V S LEN WID H E D

730507	07 38	M 089	R	1
730507	07 38	M 063	L	1
730507	07 39	M 078	R	1
730507	07 39	F 076	R	1
730507	07 39	F 084	L	1
730507	07 39	F 076	R	1
730507	07 39	F 067	R	1
730507	07 39	M 074	L	1
730507	07 39	M 062	R	1
730507	07 40	M 084	L	1
730507	07 40	F 070	R	1
730507	07 40	F 074	L	1
730507	07 40	F 080	R	1
730507	07 40	M 117	R	1
730507	07 40	M 074	R	1
730507	07 40	M 074	R	1
730514	07 03	V F 078	L	1
730514	07 03	V F 075	L	1
730514	07 03	V F 078	L	1
730514	07 03	V F 080	L	1
730514	07 04	V F 079	L	1
730514	07 04	V F 070	R	1
730514	07 04	V F 079	R	1
730514	07 04	V F 069	R	1
730514	07 06	V F 076	L	1
730514	07 06	V F 073	R	1
730514	07 06	V F 085	R	1
730514	07 06	V F 077	L	1
730514	07 06	V F 089	L	1
730514	07 06	V F 076	R	1
730514	07 06	V F 077	R	1
730514	07 07	V F 070	L	1
730514	07 07	V F 080	L	1
730514	07 07	V F 081	L	1
730514	07 07	V F 079	R	1
730514	07 08	V F 088	R	1
730514	07 08	V F 075	R	1
730514	07 08	V F 075	R	1
730514	07 08	V F 081	L	1
730514	07 08	V F 080	R	1
730514	07 08	V F 078	R	1
730514	07 09	V F 065	L	1
730514	07 09	V F 079	R	1
730514	07 09	V F 087	R	1
730514	07 09	V F 077	R	1
730514	07 09	V F 080	R	1
730514	07 31	F 075	R	1
730514	07 31	M 070	R	1
730514	07 31	M 065	L	1

LOBSTER DATA - SURFACE HAULED TRAPS
BOSTON HARBOR, MAINE 1973
DATE SDD T# V S LEN WID H E D

730514	07 31	F 080	L	1					
730514	07 31	M 073	L	1					
730514	07 32	M 075	L	1					
730514	07 32	M 077	L	1					
730514	07 33	M 068	L	1					
730514	07 33	F 087	L	1					
730514	07 32	M 069	L	1					
730514	07 34	M 077	L	1					
730514	07 34	F 084	R	1					
730514	07 35	M 078	L	1					
730514	07 36	M 081	L	1					
730514	07 36	F 045	L	1					
730514	07 36	M 076	L	1					
730514	07 36	M 069	L	1					
730514	07 36	F 068	L	1					
730514	07 37	F 079	L	1					
730514	07 37	F 082	R	1					
730514	07 37	F 068	R	1					
730514	07 37	F 074	R	1					
730514	07 37	M 067	L	1					
730514	07 38	F 082	R	1					
730514	07 38	M 064	R	1					
730514	07 38	F 067	R	1					
730514	07 38	M 070	L	1					
730514	07 38	M 077	L	1					
730514	07 38	F 069	L	1					
730514	07 38	F 068	L	1					
730514	07 38	M 076	R	1					
730514	07 39	F 074	R	1					
730514	07 39	F 072	L	1					
730514	07 39	F 072	L	1					
730514	07 40	M 079	L	1					
730514	07 40	F 070	L	1					
730514	07 40	F 092	R	1					
730514	07 40	M 080	L	1					
730514	07 40	M 082	L	1					
730523	07 03	V 079	R	1					
730523	07 03	V 092	L	1					
730523	07 04	V 074	R	1					
730523	07 04	V 072	L	1					
730523	07 04	V 081	L	1					
730523	07 04	V 073	L	1					
730523	07 04	V 071	R	1					
730523	07 05	V 069	L	1					
730523	07 05	V 074	L	1					
730523	07 05	V 078	R	1					
730523	07 05	V 076	R	1					
730523	07 05	V 075	R	1					
730523	07 05	V 072	L	1					
730523	07 05	V 077	L	1					
730523	07 05	V 076	L	1					

DATE SDD T# V S LEN WID H E D

730523	07 06	V 078	L	1					
730523	07 06	V 082	L	1					
730523	07 06	V 079	R	1					
730523	07 06	V 074	R	1					
730523	07 07	V 081	L	1					
730523	07 07	V 080	L	1					
730523	07 09	V 071	R	1					
730523	07 09	V 072	R	1					
730523	07 09	V 078	R	1					
730523	07 09	V 075	R	1					
730523	07 10	V 073	R	1					
730523	07 10	V 074	L	1					
730523	07 31	M 075	R	1					
730523	07 31	M 045	R	1					
730523	07 31	M 080	L	1					
730523	07 32	M 070	R	1					
730523	07 32	M 070	L	1					
730523	07 32	M 074	R	1					
730523	07 32	M 070	R	1					
730523	07 32	F 065	L	1					
730523	07 32	M 065	R	1					
730523	07 32	F 072	R	1					
730523	07 32	M 074	L	1					
730523	07 32	M 045	R	1					
730523	07 33	M 075	R	1					
730523	07 33	M 070	L	1					
730523	07 33	M 062	R	1					
730523	07 33	M 064	R	1					
730523	07 34	F 062	R	1					
730523	07 34	M 083	R	1					
730523	07 34	M 080	L	1					
730523	07 34	M 075	R	1					
730523	07 34	F 061	L	1					
730523	07 34	M 078	R	1					
730523	07 34	F 066	L	1					
730523	07 37	F 084	L	1					
730523	07 37	F 087	L	1					
730523	07 37	F 078	L	1					
730523	07 37	M 082	L	1					
730523	07 37	F 089	R	1					
730523	07 37	F 067	L	1					
730523	07 37	M 075	R	1					
730523	07 37	M 071	R	1					
730523	07 37	M 082	R	1					
730523	07 38	M 073	R	1					
730523	07 38	F 070	R	1					
730523	07 38	M 060	L	1					
730523	07 38	F 074	L	1					
730523	07 38	F 063	R	1					
730523	07 38	F 077	L	1					
730523	07 38	F 065	R	1					

DATE SDD T# V S LEN WID H E D

730523	07 39	F 079	L	1					
730523	07 39	F 071	L	1					
730523	07 40	M 080	L	1					
730523	07 40	F 077	R	1					
730604	12 01	V 069	L	1					
730604	12 01	V 080	L	1					
730604	12 02	V 073	R	1					
730604	12 02	V 081	R	1					
730604	12 02	V 072	R	1					
730604	12 02	V 081	R	1					
730604	12 03	V 074	R	1					
730604	12 03	V 086	L	1					
730604	12 03	V 081	R	1					
730604	12 03	V 080	L	1					
730604	12 03	V 080	L	1					
730604	12 04	V 080	L	1					
730604	12 04	V 079	R	1					
730604	12 04	V 077	R	1					
730604	12 04	V 075	R	1					
730604	12 04	V 076	L	1					
730604	12 05	V 080	L	1					
730604	12 05	V 070	R	1					
730604	12 05	V 074	R	1					
730604	12 06	V 086	R	1					
730604	12 06	V 074	R	1					
730604	12 07	V 074	L	1					
730604	12 07	V 075	R	1					
730604	12 08	V 074	R	1					
730604	12 08	V 074	R	1					
730604	12 09	V 081	L	1					
730604	12 09	V 079	L	1					
730604	12 09	V 080	L	1					
730604	12 10	V 071	L	1					
730604	12 10	V 080	L	1					
730604	12 10	V 092	L	1					
730604	12 10	V 075	R	1					
730604	12 10	V 071	R	1					
730604	12 10	V 082	R	1					
730604	12 10	V 074	L	1					
730604	12 11	M 072	L	1					
730604	12 11	F 070	L	1					
730604	12 31	F 075	L	1					
730604	12 33	F 080	L	1					
730604	12 36	F 078	R	1					
730604	12 36	F 079	R	1					
730604	12 36	F 088	L	1					
730604	12 36	M 073	L	1					
730604	12 36	M 065	L	1					
730604	12 36	M 070	L	1					
730604	12 37	M 078	R	1					
730604	12 37	F 076	L	1					

LOBSTER DATA - SURFACE HAULED TRAPS
BOSTON HARBOR, MAINE 1973
DATE SDD T# V S LEN WID H E D

730604	12 37	M 080	L	1
730604	12 37	F 076	R	1
730604	12 37	F 069	R	1
730604	12 38	M 066	R	1
730604	12 38	F 073	L	1
730604	12 38	M 075	R	1
730604	12 39	M 090	R	1
730604	12 39	F 081	R	1
730604	12 39	M 068	R	1
730604	12 40	F 070	L	1
730604	12 40	F 076	R	1
730604	12 40	F 086	L	1
730604	12 40	M 071	L	1
730604	12 40	M 076	L	1
730604	12 40	M 089	L	1
730604	12 40	M 070	R	1
730611	07 01 V	M 081	L	1
730611	07 01 V	M 074	L	1
730611	07 02	V 077	L	1
730611	07 02	V 078	R	1
730611	07 02	V 070	R	1
730611	07 02	V 069	R	1
730611	07 03	V 078	R	1
730611	07 03	V 080	R	1
730611	07 03	V 087	L	1
730611	07 04	V 079	R	1
730611	07 04	V 074	M	1
730611	07 05	V 069	R	1
730611	07 05	V 062	L	1
730611	07 06	V 078	L	1
730611	07 06	V 071	L	1
730611	07 06	V 079	L	1
730611	07 06	V 080	L	1
730611	07 08	V 068	R	1
730611	07 08	V 076	R	1
730611	07 08	V 074	R	1
730611	07 08	V 078	R	1
730611	07 09	V 079	R	1
730611	07 09	V 085	R	1
730611	07 09	V 076	R	1
730611	07 09	V 077	R	1
730611	07 10	V 080	R	1
730611	07 10	V 082	L	1
730611	07 11	M 075	R	1
730611	07 11	M 078	R	1
730611	07 11	M 081	R	1
730611	07 11	M 084	R	1
730611	07 11	M 072	R	1
730611	07 11	M 073	R	1
730611	07 11	M 070	R	1
730611	07 35	F 067	R	1
730611	07 35	F 067	R	1

LOBSTER DATA - SURFACE HAULED TRAPS
BOOTHBAY HARBOR, MAINE 1973

DATE SDD T# V S LEN WID H E D

730627	09 38	F 078	L	1
730627	09 38	M 072	L	1
730627	09 38	M 077	L	1
730627	09 38	F 075	R	1
730627	07 38	M 080	L	1
730627	07 38	M 069	R	1
730627	09 39	F 075	R	1
730627	09 39	M 073	L	1
730627	09 39	F 084	R	1
730627	07 39	M 078	L	1
730627	07 39	M 078	L	1
730627	09 40	M 079	R	1
730627	09 40	M 080	L	1
730703	07 01	V F 070	L	1
730703	07 01	V F 073	L	1
730703	07 01	V F 064	R	1
730703	07 01	V F 071	R	1
730703	07 02	V F 079	L	1
730703	07 03	V F 078	L	1
730703	07 04	V F 073	R	1
730703	07 04	V F 078	R	1
730703	07 04	V F 070	R	1
730703	07 05	V F 073	R	1
730703	07 05	V F 071	R	1
730703	07 05	V M 043	L	1
730703	07 05	V M 043	R	1
730703	07 05	V F 071	L	1
730703	07 06	V F 080	L	1
730703	07 06	V F 073	L	1
730703	07 06	V M 073	L	1
730703	07 06	V F 073	L	1
730703	07 07	V F 073	L	1
730703	07 07	V M 078	L	1
730703	07 07	V F 079	R	1
730703	07 08	V M 081	R	1
730703	07 08	V M 069	R	1
730703	07 08	V M 069	L	1
730703	07 08	V F 073	R	1
730703	07 08	V F 085	L	1
730703	07 09	V F 071	L	1
730703	07 09	V F 072	L	1
730703	07 09	V M 080	L	1
730703	07 10	V F 008	L	1
730703	07 10	V F 068	R	1
730703	07 10	V F 074	R	1
730703	07 10	V F 072	L	1
730703	07 10	V F 076	R	1
730703	07 10	V F 076	R	1
730703	07 10	V F 071	R	1

DATE SDD T# V S LEN WID H E D

730703	07 31	F 071	L	1
730703	07 31	M 067	L	1
730703	07 32	M 067	R	1
730703	07 33	F 078	L	1
730710	07 01	V M 072	L	1
730710	07 03	V F 076	L	1
730710	07 03	V F 078	L	1
730710	07 04	V F 074	L	1
730710	07 04	V M 074	L	1
730710	07 04	V F 139	L	1
730710	07 04	V F 079	L	1
730710	07 05	V F 077	L	1
730710	07 05	V M 073	L	1
730710	07 05	V M 074	R	1
730710	07 06	V F 081	L	1
730710	07 06	V F 077	L	1
730710	07 07	V M 081	L	1
730710	07 08	V M 066	L	1
730710	07 08	V F 071	L	1
730710	07 08	V F 063	L	1
730710	07 09	V M 079	R	1
730710	07 09	V F 077	R	1
730710	07 10	V F 093	L	1
730710	07 10	V M 068	L	1
730710	07 10	V M 080	R	1
730710	07 32	M 080	R	1
730710	07 32	F 073	R	1
730710	07 33	F 078	L	1
730710	07 33	F 067	R	1
730710	07 34	F 080	R	1
730710	07 34	F 077	R	1
730710	07 34	M 066	R	1
730710	07 34	M 067	R	1
730710	07 34	M 074	R	1
730710	07 34	F 080	L	1
730710	07 35	F 079	R	1
730710	07 35	F 091	R	1
730710	07 35	M 081	R	1
730710	07 35	M 079	R	1
730710	07 36	M 076	R	1
730710	07 36	F 075	R	1
730710	07 37	F 073	R	1
730710	07 37	F 080	R	1
730710	07 37	M 072	L	1
730710	07 37	F 077	R	1
730710	07 38	F 075	L	1
730710	07 38	M 079	L	1
730710	07 38	F 081	R	1

DATE SDD T# V S LEN WID H E D

730710	07 38	F 077	R	1
730710	07 38	M 074	L	1
730710	07 38	M 077	R	1
730710	07 38	F 073	R	1
730710	07 39	M 083	R	1
730710	07 39	M 080	R	1
730710	07 39	F 080	R	1
730710	07 40	F 078	R	1
730710	07 40	M 075	L	1
730717	07 01	V F 082	R	1
730717	07 01	V M 082	L	1
730717	07 01	V M 079	R	1
730717	07 02	V F 073	R	1
730717	07 03	V F 081	R	1
730717	07 04	V F 071	L	1
730717	07 04	V M 080	R	1
730717	07 05	V M 075	R	1
730717	07 05	V M 080	L	1
730717	07 05	V M 075	R	1
730717	07 06	V M 077	R	1
730717	07 06	V F 081	L	1
730717	07 06	V M 080	L	1
730717	07 06	V F 074	R	1
730717	07 06	V F 074	R	1
730717	07 07	V F 080	L	1
730717	07 08	V M 073	R	1
730717	07 09	V F 072	L	1
730717	07 09	V F 084	R	1
730717	07 31	F 076	L	1
730717	07 31	F 065	L	1
730717	07 32	M 073	R	1
730717	07 33	F 073	R	1
730717	07 33	F 068	R	1
730717	07 33	M 076	L	1
730717	07 33	M 071	R	1
730717	07 34	M 077	L	1
730717	07 34	F 072	R	1
730717	07 34	F 078	L	1
730717	07 35	M 078	R	1
730717	07 35	F 077	L	1
730717	07 35	F 113	L	1
730717	07 35	F 066	R	1
730717	07 35	F 073	R	1
730717	07 35	M 064	R	1
730717	07 35	M 078	R	1
730717	07 36	F 079	L	1
730717	07 36	F 065	L	1
730717	07 36	F 075	R	1
730717	07 36	F 081	L	1

LOBSTER DATA - SURFACE HAULED TRAPS
BOOTHBAY HARBOR, MAINE 1973

DATE SDD T# V S LEN WID H E D

730717	07 36	M 072	R	1
730717	07 36	F 071	L	1
730717	07 36	M 070	L	1
730717	07 37	M 063	R	1
730717	07 37	M 096	R	1
730717	07 37	F 079	L	1
730717	07 37	M 065	L	1
730717	07 37	F 090	L	1
730717	07 37	M 082	L	1
730717	07 37	M 079	L	1
730717	07 38	F 080	L	1
730717	07 38	M 073	L	1
730717	07 38	M 071	R	1
730717	07 38	M 074	L	1
730717	07 39	F 078	R	1
730717	07 39	F 071	R	1
730717	07 39	F 079	L	1
730717	07 39	M 080	L	1
730717	07 39	M 075	L	1
730717	07 39	M 080	L	1
730717	07 40	F 066	L	1
730717	07 40	M 068	R	1
730717	07 40	F 074	R	1
730717	07 40	F 068	R	1
730717	07 40	F 092	R	1
730723	06 01	V F 074	R	1
730723	06 02	V F 092	R	1
730723	06 03	V F 073	L	1
730723	06 04	V M 072	L	1
730723	06 04	V F 066	L	1
730723	06 05	V M 078	L	1
730723	06 05	V F 075	L	1
730723	06 05	V F 078	L	1
730723	06 05	V F 079	L	1
730723	06 05	V M 088	L	1
730723	06 05	V F 080	L	1
730723	06 07	V M 089	R	1
730723	06 07	V F 084	R	1
730723	06 07	V F 084	L	1
730723	06 08	V F 078	R	1
730723	06 08	V F 081	L	1
730723	06 09	V F 078	L	1
730723	06 09	V F 079	R	1
730723	06 10	V F 076	L	1
730723	06 10	V F 073	L	1
730723	06 10	V M 083	L	1
730723	06 31	F 075	L	1
730723	06 31	F 076	L	1

DATE SDD T# V S LEN WID H E D

730723	06 31	M 078	L	1
730723	06 32	F 074	L	1
730723	06 33	F 076	L	1
730723	06 33	M 074	R	1
730723	06 34	M 081	R	1
730723	06 34	M 064	R	1
730723	06 34	M 066	L	1
730723	06 35	F 080	R	1
730723	06 35	F 063	R	1
730723	06 35	M 082	R	1
730723	06 36	F 074	L	1
730723	06 36	F 094	R	1
730723	06 36	F 080	L	1
730723	06 36	F 029	L	1
730723	06 36	F 087	L	1
730723	06 36	M 078	L	1
730723	06 36	M 072	L	1
730723	06 37	M 075	L	1
730723	06 37	M 076	L	1
730723	06 37	F 072	L	1
730723	06 37	M 073	L	1
730723	06 39	F 083	R	1
730723	06 39	F 074	L	1
730723	06 40	M 094	R	1
730723	06 40	F 078	R	1
730723	06 40	F 065	R	1
730723	06 01	V M 080	L	1
730731	08 02	V F 105	L	1
730731	08 02	V M 078	L	1
730731	08 04	V F 073	R	1
730731	08 04	V F 074	R	1
730731	08 05	V M 092	L	1
730731	08 05	V M 080	L	1
730731	08 05	V M 074	L	1
730731	08 05	V F 078	R	1
730731	08 06	V F 081	R	1
730731	08 07	V F 090	R	1
730731	08 07	V F 079	L	1
730731	08 10	V M 079	R	1
730731	08 10	V M 081	R	1
730731	08 10	V F 080	R	1
730731	08 10	V M 086	R	1
730731	08 31	F 076	L	1
730731	08 31	M 072	L	1
730731	08 31	M 074	L	1

DATE SDD T# V S LEN WID H E D

730731	08 31	M 093	L	1
730731	08 31	F 086	R	1
730731	08 31	F 078	R	1
730731	08 32	F 070	R	1
730731	08 32	F 074	L	1
730731	08 32	F 072	R	1
730731	08 33	F 044	R	1
730731	08 33	M 079	L	1
730731	08 33	F 077	L	1
730731	08 33	M 075	R	1
730731	08 34	M 078	R	1
730731	08 36	M 070	R	1
730731	08 36	M 075	L	1
730731	08 36	M		
730731	08 36	M 080		
730731	08 39	M 080		
730731	08 39	M 083		
730731	08 40	F 087		
730731	08 40	F 072		
730731	08 40	M 075		
730731	08 40	F 086		
730731	08 40	F 083		
730731	08 40	M 093		
730731	08 40	F 074		
730806	02 02	M 081	R	1
730806	02 02	M 079	R	1
730806	02 02	F 086	R	1
730806	02 03	M 085	R	1
730806	02 04	F 069	R	1
730806	02 04	M 074	R	1
730806	02 04	M 080	R	1
730806	02 04	F 074	L	1
730806	02 04	F 071	L	1
730806	02 04	F 076	L	1
730806	02 05	F 084	L	1
730806	02 05	M 075	R	1
730806	02 05	F 080	L	1
730806	02 05	M 069	L	1
730806	02 06	F 067	L	1
730806	02 06	M 076	L	1
730806	02 06	F 068	L	1
730806	02 06	M 068	L	1
730806	02 06	M 077	R	1
730806	02 06	M 082	R	1
730806	02 06	M 081	R	1
730806	02 06	F 089	R	1
730806	02 07	F 091	R	1
730806	02 07	M 086	R	1
730806	02 07	F 077	R	1
730806	02 08	F 087	R	1
730806	02 08	F 073	L	1

LOBSTER DATA - SURFACE HAULED TRAPS
BOOTHBAY HARBOR, MAINE 1973
DATE SBD T# V S LEN WID H E D

730806	06	08	V	F	071	L	1
730806	06	08	V	M	066	L	1
730806	06	08	V	F	070	L	1
730806	06	08	V	F	077	L	1
730806	06	08	V	F	079	L	1
730806	06	08	V	F	079	R	1
730806	06	08	V	M	075	L	1
730806	06	08	V	F	079	L	1
730806	06	08	V	F	080	L	1
730806	06	09	V	M	072	R	1
730806	06	09	V	F	075	R	1
730806	06	09	V	M	070	R	1
730806	06	10	V	F	077	L	1
730806	06	10	V	F	081	R	1
730806	06	10	V	F	077	L	1
730806	06	10	V	F	073	L	1
730806	06	10	V	M	065	L	1
730806	06	10	V	M	064	L	1
730806	06	10	V	M	084	L	1
730806	06	31	F	072	L	1	
730806	06	31	F	069	L	1	
730806	06	31	M	078	L	1	
730806	06	31	F	067	L	1	
730806	06	31	F	081	L	1	
730806	06	32	M	072	L	1	
730806	06	32	F	070	R	1	
730806	06	32	F	072	R	1	
730806	06	32	F	086	R	1	
730806	06	33	M	085	L	1	
730806	06	33	F	073	L	1	
730806	06	33	M	091	L	1	
730806	06	33	F	068	R	1	
730806	06	33	F	080	R	1	
730806	06	34	M	073	R	1	
730806	06	34	F	079	R	1	
730806	06	35	M	078	L	1	
730806	06	35	F	081	L	1	
730806	06	35	M	080	L	1	
730806	06	35	F	072	L	1	
730806	06	35	F	071	L	1	
730806	06	35	F	065	L	1	
730806	06	35	M	079	L	1	
730817	11	01	V	F	080	L	1
730817	11	01	V	F	080	L	1
730817	11	01	V	F	088	L	1
730817	11	02	V	M	088	L	1
730817	11	02	V	F	084	L	1
730817	11	02	V	F	077	L	1
730817	11	02	V	F	079	L	1

DATE SBD T# V S LEN WID H E D

730817	11	02	V	M	077	R	1
730817	11	02	V	F	091	L	1
730817	11	02	V	F	081	L	1
730817	11	04	V	F	072	R	1
730817	11	04	V	F	085	R	1
730817	11	04	V	M	091	R	1
730817	11	04	V	M	074	R	1
730817	11	06	V	M	085	L	1
730817	11	06	V	F	078	L	1
730817	11	06	V	F	087	L	1
730817	11	06	V	F	093	L	1
730817	11	07	V	F	086	L	1
730817	11	07	V	M	087	L	1
730817	11	07	V	F	088	L	1
730817	11	08	V	M	080	L	1
730817	11	08	V	M	092	L	1
730817	11	08	V	F	088	L	1
730817	11	08	V	F	089	L	1
730817	11	09	V	M	105	L	1
730817	11	09	V	F	074	L	1
730817	11	09	V	F	077	L	1
730817	11	09	V	F	081	L	1
730817	11	09	V	F	080	L	1
730817	11	31	F	080	R	1	
730817	11	31	F	092	R	1	
730817	11	31	F	089	R	1	
730817	11	31	F	079	L	1	
730817	11	31	F	073	L	1	
730817	11	31	F	074	L	1	
730817	11	31	F	068	L	1	
730817	11	32	F	066	L	1	
730817	11	32	M	073	L	1	
730817	11	32	F	077	L	1	
730817	11	32	M	070	L	1	
730817	11	33	F	075	R	1	
730817	11	33	F	074	R	1	
730817	11	33	M	076	R	1	
730817	11	33	F	063	R	1	
730817	11	34	F	082	L	1	
730817	11	34	F	075	L	1	
730817	11	34	M	073	L	1	
730817	11	35	F	088	L	1	
730817	11	35	M	078	L	1	
730817	11	35	M	068	L	1	
730817	11	35	M	077	L	1	
730817	11	36	M	079	L	1	
730817	11	37	M	078	L	1	
730817	11	37	M	080	L	1	
730817	11	37	F	077	L	1	

DATE SBD T# V S LEN WID H E D

730817	11	37	F	074	L	1	
730817	11	37	F	083	L	1	
730817	11	38	M	082	L	1	
730817	11	38	M	072	L	1	
730817	11	38	M	079	L	1	
730817	11	38	M	081	L	1	
730817	11	39	F	070	M	1	
730817	11	39	M	088	L	1	
730817	11	40	M	078	L	1	
730817	11	40	F	081	L	1	
730821	04	01	V	F	104	L	1
730821	04	01	V	M	085	R	1
730821	04	01	V	F	092	L	1
730821	04	01	V	F	079	L	1
730821	04	02	V	M	084	L	1
730821	04	03	V	M	068	L	1
730821	04	03	V	M	071	L	1
730821	04	04	V	F	070	L	1
730821	04	04	V	F	080	L	1
730821	04	04	V	M	076	L	1
730821	04	04	V	F	092	L	1
730821	04	04	V	M	074	L	1
730821	04	04	V	F	075	L	1
730821	04	06	V	F	082	L	1
730821	04	06	V	F	074	R	1
730821	04	06	V	F	102	R	1
730821	04	06	V	F	075	R	1
730821	04	06	V	M	078	L	1
730821	04	07	V	M	080	L	1
730821	04	07	V	M	080	L	1
730821	04	07	V	F	093	L	1
730821	04	07	V	F	084	L	1
730821	04	08	V	M	080	R	1
730821	04	08	V	F	085	R	1
730821	04	08	V	F	074	R	1
730821	04	08	V	M	077	L	1
730821	04	08	V	F	081	L	1
730821	04	09	V	F	073	L	1
730821	04	09	V	F	073	L	1
730821	04	09	V	F	077	L	1
730821	04	09	V	F	079	L	1
730821	04	10	V	F	084	L	1
730821	04	31	M	091	L	1	
730821	04	31	M	070	L	1	
730821	04	31	F	075	L	1	
730821	04	32	M	063	L	1	
730821	04	32	M	071	L	1	
730821	04	32	F	074	L	1	
730821	04	32	F	026	L	1	

LOBSTER DATA - SURFACE HAULED TRAPS
BOOTHBAY HARBOR, MAINE 1973
DATE SBD T# V S LEN WID H E D

730821	04	32	F	074	R	1	
730821	04	32	M	082	L	1	
730821	04	33	F	078	L	1	
730821	04	33	M	078	L	1	
730821	04	33	M	075	L	1	
730821	04	34	F	068	L	1	
730821	04	34	M	079	R	1	
730821	04	34	M	074	R	1	
730821	04	34	F	082	R	1	
730821	04	34	M	077	R	1	
730821	04	34	M	078	L	1	
730821	04	34	F	074	L	1	
730821	04	35	F	098	L	1	
730821	04	35	F	072	L	1	
730821	04	35	F	080	L	1	
730821	04	35	M	040	L	1	
730821	04	36	M	040	L	1	
730821	04	37	M	062	L	1	
730821	04	37	F	078	L	1	
730821	04	37	F	077	L	1	
730821	04	37	M	079	L	1	
730821	04	37	M	076	L	1	
730821	04	38	M	078	L	1	
730821	04	38	F	080	L	1	
730821	04	38	F	075	R	1	
730821	04	38	M	076	R	1	
730821	04	39	F	081	L	1	
730821	04	39	F	091	L	1	
730821	04	39	M	071	R	1	
730821	04	39	M	074	L	1	
730821	04	40	M	092	L	1	
730821	04	40	M	073	L	1	
730828	07	01	V	F	072	L	1
730828	07	01	V	F	085	L	1
730828	07	01	V	M	080	L	1
730828	07	01	V	M	075	L	1
730828	07	01	V	F	079	R	1
730828	07	02	V	F	082	R	1
730828	07	02	V	F	077	R	1
730828	07	02	V	M	078	L	1
730828	07	02	V	F	092	L	1
730828	07	02	V	M	069	R	1
730828	07	03	V	F	079	L	1
730828	07	03	V	M	078	L	1
730828	07	03	V	F	080	L	1
730828	07	04	V	F	068	L	1
730828	07	04	V	F	080	L	1

DATE SBD T# V S LEN WID H E D

730828	07	04	V	M	080	R	1
730828	07	04	V	M	074	L	1
730828	07	04	V	M	077	L	1
730828	07	04	V	M	072	L	1
730828	07	05	V	M	068	R	1
730828	07	05	V	F	072	R	1
730828	07	05	V	F	075	R	1
730828	07	05	V	M	078	R	1
730828	07	05	V	M	076	R	1
730828	07	06	V	M	080	R	1
730828	07	06	V	F	076	L	1
730828	07	07	V	F	079	L	1
730828	07	08	V	F	076	L	1
730828	07	08	V	M	107	L	1
730828	07	08	V	F	071	L	1
730828	07	08	V	F	084	L	1
730828	07	09	V	M	075	L	1
730828	07	09	V	M	073	F	091
730828	07	31	F	M	086	L	1
730828	07	31	F	M	090	L	1
730828	07	31	F	M	094	L	1
730828	07	31	F	M	076	L	1
730828	07	32	F	M	086	L	1
730828	07	32	F	M	077	L	1
730828	07	32	F	M	077	L	1
730828	07	32	F	M	081	R	1
730828	07	32	F	M	073	R	1
730828	07	32	F	M	080	R	1
730828	07	32	F	M	077	R	1
730828	07	32	F	M	072	R	1
730828	07	33	M	M	070	L	1
730828	07	33	F	M	078	F	078
730828	07	33	F	M	082	R	1
730828	07	33	F	M	080	R	1
730828	07	33	F	M	081	R	1
730828	07	33	M	M	088	L	1
730828	07	33	F	M	082	L	1
730828	07	33	F	M	080	R	1
730828	07	33	M	M	068	L	1
730828	07	34	F	M	084	L	1
730828	07	34	F	M	080	L	1
730828	07	34	F	M	073	L	1
730828	07	34	F	M	078	L	1
730828	07	34	F	M	070	L	1
730828	07	34	F	M	083	L	1
730828	07	34	F	M	077	L	1
730828	07	34	M	M	089	L	1

LOBSTER DATA - SURFACE HAULED TRAPS
BOOTHBAY HARBOR, MAINE 1973

DATE	SSD	T#	V	S	LEN	WID	H	E	D
730830	02	32	F	080					
730830	02	32	F	075					
730830	02	32	M	077					
730830	02	33	F	083					
730830	02	33	F	071					
730830	02	33	F	070					
730830	02	33	F	086					
730830	02	35	F	067					
730830	02	35	F	079					
730830	02	35	M	068					
730830	02	35	F	079					
730830	02	36	F	079					
730830	02	36	F	085					
730830	02	36	F	079					
730830	02	36	F	080					
730830	02	36	F	071					
730830	02	36	M	077					
730830	02	36	M	075					
730830	02	36	F	075					
730830	02	36	F	070					
730830	02	36	M	077					
730830	02	36	F	067					
730830	02	36	F	068					
730830	02	36	F	061					
730830	02	37	F	073					
730830	02	38	F	075					
730830	02	39	M	068					
730830	02	39	M	071					
730830	02	39	F	068					
730830	02	40	M	070					
730830	02	40	M	067					

LOBSTER DATA - SURFACE HAULED TRAPS
MOOSE HOLE, MA 1974

DATE	SSD	T#	V	S	LEN	WID	H	E	D
740514	05	41	V	M	077				
740514	05	41	V	F	076				
740514	05	41	V	F	078				
740514	05	41	V	M	076				
740514	05	42	V	F	071				
740514	05	42	V	F	073				
740514	05	42	V	M	079				
740514	05	42	V	F	079				
740514	05	43	V	M	078				
740514	05	43	V	M	079				
740514	05	44	V	M	078				
740514	05	44	V	F	080				
740514	05	44	V	M	069				
740514	05	45	V	F	075				
740514	05	45	V	M	079				
740514	05	45	V	M	078				
740514	05	46	V	M	078				
740514	05	46	V	F	075				
740514	05	46	V	F	069				
740514	05	46	V	M	074				
740514	05	46	V	F	076				
740514	05	47	V	M	060				
740514	05	47	V	F	067				
740514	05	47	V	F	078				
740514	05	48	V	M	075				
740514	05	48	V	M	082				
740514	05	48	V	M	086				
740514	05	48	V	F	067				
740514	05	49	V	F	074				
740514	05	49	V	M	086				
740514	05	49	V	F	077				
740514	05	50	V	F	080				
740514	05	50	V	F	063				
740514	05	50	V	M	079				
740514	05	50	V	M	079				
740514	05	51	M	057					
740514	05	51	F	060					
740514	05	51	M	078					
740514	05	52	M	079					
740514	05	52	M	074					
740514	05	52	F	067					
740514	05	52	M	076					
740514	05	52	M	074					
740514	05	53	F	067					
740514	05	53	M	071					
740514	05	53	F	066					
740514	05	53	M	081					
740514	05	53	M	068					
740514	05	53	M	075					
740514	05	53	M	075					

DATE	SSD	T#	V	S	LEN	WID	H	E	D
740514	05	53	M	076					
740514	05	54	M	070					
740514	05	54	M	083					
740514	05	55	M	071					
740514	05	55	F	067					
740514	05	55	M	068					
740514	05	55	M	069					
740514	05	55	M	070					
740514	05	55	F	073					
740514	05	57	F	069					
740514	05	58	F	063					
740514	05	58	F	069					
740514	05	59	M	075					
740514	07	41	V	F	086	053			
740521	07	42	V	F	082	051			
740521	07	42	V	M	081	049			
740521	07	42	V	M	077	046			
740521	07	43	V	M	076	046			
740521	07	43	V	M	077	046			
740521	07	43	V	M	077	047			
740521	07	43	V	M	078	046			
740521	07	43	V	M	080	048			
740521	07	44	V	M	078	046			
740521	07	44	V	F	075	048			
740521	07	44	V	F	060	035			
740521	07	44	V	M	086	082			
740521	07	44	V	F	076	046			
740521	07	44	V	F	081	049			
740521	07	45	V	F	075	048			
740521	07	45	V	F	077	048			
740521	07	45	V	M	075				
740521	07	45	V	F	078	048			
740521	07	45	V	M	092	056			
740521	07	45	V	F	078	050			
740521	07	46	V	F	077	050			
740521	07	46	V	M	078	048			
740521	07	46	V	M	077	047			
740521	07	46	V	M	079	048			
740521	07	47	V	M	079	048			
740521	07	47	V	F	076	047			
740521	07	48	V	F	077	048			
740521	07	48	V	F	079	047			
740521	07	49	V	F	077	048			
740521	07	52	F	075	040				
740521	07	52	F	068	041				
740521	07	52	M	073	043				
740521	07	52	F	078	047				
740521	07	52	M	071	043				
740521	07	52	F	074	043				
740521	07	52	F	082	051				
740521	07	52	F	080	048				

LOBSTER DATA - SURFACE HAULED TRAPS
MOOSE HOLE, MA 1974

DATE	SSD	T#	V	S	LEN	WID	H	E	D
740521	07	52	M	075	045	R	1		
740521	07	53	F	077	048	R	2		
740521	07	53	F	084	054	R	1		
740521	07	53	M	078	046	R	1		
740521	07	53	M	078	048	R	1		
740521	07	54	M	072	044	L	1		
740521	07	54	F	074	047	R	1		
740521	07	54	M	082	052	R	1		
740521	07	54	M	072	044	L	1		
740521	07	54	F	069	043	L	2		
740521	07	55	F	073	046	L	1		
740521	07	55	M	075	045	L	1		
740521	07	55	M	074	045	L	1		
740521	07	55	M	071	041	L	1		
740521	07	55	F	078	049	R	1		
740521	07	55	M	072	043	L	1		
740521	07	55	F	077	046	R	1		
740521	07	55	M	073	045	R	1		
740521	07	55	M	074	044	R	1		
740521	07	55	M	073	046	L	1		
740521	07	55	F	080	049	R	2		
740521	07	55	F	076	048	R	1		
740521	07	55	M	073	049	R	1		
740521	07	55	M	074	047	L	1		
740521	07	55	F	074	046	R	1		
740521	07	55	M	075	044	L	1		
740521	07	55	M	078	047	L	1		
740521	07	55	F	070	042	L	1		
740521	07	55	F	066	039	L	1		
740521	07	57	M	075	046	L	1		
740521	07	57	M	078	044	L	1		
740521	07	57	M	072	043	L	1		
740521	07	57	M	077	046	L	1		
740521	07	57	M	071	043	L	1		
740521	07	57	F	070	043	R	1		
740521	07	57	M	067	039	L	1		
740521	07	58	M	076	048	R	1		
740521	07	58	F	076	048	R	1		
740521	07	58	M	070	043	L	1		
740521	07	58	M	084	051	R	1		
740521	07	59	M	072	044	L	1		
740521	07	59	M	068	041	L	1		
740521	07	59	M	083	052	L	1		
740521	07	59	M	074	046	L	1		
740521	07	59	F	077	049	R	2		
740521	07	59	M	081	049	R	1		
740521	07	60	M	070	041	R	1		
740521	07	60	F	074	046	L	1		

LOBSTER DATA - SURFACE HAULED TRAPS

HOBBS HOLE, MA, 1974

DATE SDD T# V S LEN WID H E D

740528 05 52 F 074 044 R 2 1
 740528 05 52 F 071 043 R 1 1
 740528 05 52 F 067 037 L 1 1
 740528 05 52 F 074 043 L 1 1
 740528 05 52 F 071 041 L 1 1
 740528 05 53 M 065 039 R 1 1
 740528 05 53 M 070 039 R 1 1
 740528 05 53 F 066 039 L 1 1
 740528 05 53 F 072 042 L 1 1
 740528 05 53 F 075 044 L 1 1
 740528 05 53 F 071 041 L 1 1
 740528 05 53 M 070 040 R 1 1
 740528 05 53 F 073 041 R 1 1
 740528 05 53 F 077 043 L 2 1
 740528 05 53 F 077 043 L 2 1
 740528 05 53 M 074 040 R 1 1
 740528 05 53 F 073 041 R 1 1
 740528 05 53 M 069 037 L 1 1
 740528 05 53 F 067 040 R 1 1
 740528 05 53 F 063 036 L 1 1
 740528 05 53 F 073 043 R 2 1
 740528 05 53 F 071 040 L 1 1
 740528 05 53 M 070 042 R 1 1
 740528 05 54 M 076 043 R 1 1
 740528 05 54 F 075 044 R 1 1
 740528 05 54 M 083 049 L 1 1
 740528 05 54 F 070 042 L 1 1
 740528 05 54 M 085 050 R 1 1
 740528 05 54 F 074 R 1 1
 740528 05 54 M 079 044 L 1 1
 740528 05 54 M 076 045 R 1 1
 740528 05 54 M 077 044 L 1 1
 740528 05 54 F 033 042 L 2 1
 740528 05 54 F 077 046 R 1 1
 740528 05 54 M 074 042 L 1 1
 740528 05 54 F 072 043 L 1 1
 740528 05 55 M 072 043 R 1 1
 740528 05 55 F 074 043 R 1 1
 740528 05 55 F 061 035 R 1 1
 740528 05 55 F 075 045 L 1 1
 740528 05 55 F 069 040 L 1 1
 740528 05 55 M 067 037 L 1 1
 740528 05 55 M 080 049 R 1 1
 740528 05 55 M 079 046 R 1 1
 740528 05 55 M 066 037 L 1 1
 740528 05 55 M 067 039 R 1 1
 740528 05 56 F 075 045 R 2 1
 740528 05 56 F 077 045 R 1 1
 740528 05 57 F 072 044 L 1 1
 740528 05 57 F 070 042 R 1 1
 740528 05 57 F 074 043 R 1 1
 740528 05 57 F 065 037 L 1 1

DATE SDD T# V S LEN WID H E D

740528 05 58 F 073 042 L 1 1
 740528 05 58 F 075 043 L 1 1
 740528 05 58 F 079 045 R 1 1
 740528 05 58 M 073 043 R 1 1
 740528 05 58 M 075 042 L 1 1
 740528 05 58 F 079 048 R 1 1
 740528 05 58 M 076 043 L 1 1
 740528 05 58 F 071 041 R 1 1
 740528 05 58 F 080 050 L 2 1
 740528 05 59 F 073 045 L 2 1
 740528 05 59 F 069 037 L 1 1
 740528 05 59 F 073 043 L 1 1
 740528 05 59 M 078 043 R 1 1
 740528 05 59 M 069 039 R 1 1
 740528 05 59 M 074 043 R 1 1
 740528 05 59 F 075 045 L 1 1
 740528 05 59 F 039 048 L 1 1
 740528 05 59 M 074 041 L 1 1
 740528 05 59 M 071 042 L 1 1
 740528 05 59 F 074 043 R 1 1
 740528 05 59 M 070 040 L 1 1
 740528 05 59 F 069 041 L 1 1
 740528 05 59 M 069 039 R 1 1
 740528 05 60 M 076 043 R 1 1
 740528 05 60 M 070 040 R 1 1
 740528 05 60 F 067 038 R 1 1
 740528 05 60 M 071 041 R 1 1
 740528 05 60 M 079 040 R 1 1
 740528 05 60 F 073 041 L 1 1
 740528 05 60 F 083 050 L 1 1
 740528 05 60 M 084 050 L 1 1
 740528 05 60 M 069 039 R 1 1
 740528 05 60 F 074 043 R 1 1
 740528 05 60 M 077 043 R 1 1
 740528 05 60 M 074 041 L 1 1
 740528 05 60 M 077 044 R 1 1
 740528 05 60 M 069 039 R 1 1
 740528 05 60 F 078 045 L 1 1
 740528 05 60 F 070 041 R 1 1
 740528 05 60 M 067 036 L 1 1
 740528 05 60 F 074 044 L 1 1
 740528 05 60 F 067 038 R 1 1
 740528 05 60 F 065 036 R 1 1
 740530 02 41 V F 075 046 L 2 1
 740530 02 42 V F 077 046 L 1 1
 740530 02 42 V F 079 048 L 1 1
 740530 02 43 V M 080 048 R 1 1
 740530 02 44 V M 078 044 R 1 1
 740530 02 44 V M 078 045 L 1 1
 740530 02 44 V M 080 051 R 1 1
 740530 02 44 V M 077 047 R 1 1

DATE SDD T# V S LEN WID H E D

740530 02 44 V M 085 052 L 1 1
 740530 02 46 V F 078 048 L 1 1
 740530 02 47 V F 076 045 R 1 1
 740530 02 48 V F 077 045 R 2 1
 740530 02 49 V M 080 046 R 1 1
 740530 02 50 V M 079 046 R 1 1
 740530 02 50 V F 078 045 R 2 1
 740530 02 51 M 078 047 R 1 1
 740530 02 51 M 085 036 L 1 1
 740530 02 52 F 070 044 L 2 1
 740530 02 52 M 079 046 R 1 1
 740530 02 52 F 065 038 R 1 1
 740530 02 52 M 075 047 L 1 1
 740530 02 52 F 074 043 R 1 1
 740530 02 52 M 072 042 L 1 1
 740530 02 52 M 075 045 L 1 1
 740530 02 52 M 074 045 R 1 1
 740530 02 52 F 066 037 R 1 1
 740530 02 52 F 067 040 R 1 1
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 740530 02 53 F 085 035 L 1 1
 740530 02 53 F 073 044 R 2 1
 740530 02 53 F 074 042 R 1 1
 740530 02 53 M 074 043 L 1 1
 740530 02 54 M 075 044 R 1 1
 740530 02 54 F 066 040 R 1 1
 740530 02 54 F 071 044 L 1 1
 740530 02 54 M 073 044 R 1 1
 740530 02 54 M 075 045 R 1 1
 740530 02 54 F 073 044 R 2 1
 740530 02 55 M 073 042 R 1 1
 740530 02 55 F 073 045 L 2 1
 740530 02 55 M 070 041 R 1 1
 740530 02 55 M 074 045 L 1 1
 740530 02 55 M 071 043 R 1 1
 740530 02 55 F 083 050 L 1 1
 740530 02 58 M 075 045 L 1 1
 740530 02 59 F 066 040 L 1 1
 740530 02 59 F 073 040 R 1 1
 740530 02 59 M 075 045 R 1 1
 740530 02 59 M 072 044 L 1 1
 740530 02 59 F 066 038 R 1 1
 740530 02 60 F 075 047 R 1 1
 740530 02 60 M 066 041 R 1 1
 740530 02 60 M 067 039 L 1 1
 740530 02 60 F 067 039 L 1 1
 740530 02 60 F 075 045 R 1 1
 740530 02 60 F 080 048 R 1 1

LOBSTER DATA - SURFACE HAULED TRAPS

HOBBS HOLE, MA, 1974

DATE SDD T# V S LEN WID H E D

740603 02 60 F 078 046 R 2 1
 740603 02 60 M 071 045 L 1 1
 740603 02 60 F 065 037 L 1 1
 740603 04 41 V F 078 041 R 1 1
 740603 04 42 V F 077 047 R 1 1
 740603 04 42 V M 079 046 R 1 1
 740603 04 43 V M 083 043 L 1 1
 740603 04 43 V F 072 040 R 1 1
 740603 04 43 V F 074 047 L 1 1
 740603 04 44 V F 084 053 R 2 1
 740603 04 44 V M 080 046 R 1 1
 740603 04 44 V F 076 046 L 1 1
 740603 04 45 V F 077 047 L 2 1
 740603 04 45 V F 079 048 L 1 1
 740603 04 46 V M 071 040 L 1 1
 740603 04 46 V F 087 052 L 1 1
 740603 04 47 V F 080 040 L 2 1
 740603 04 47 V F 078 048 R 2 1
 740603 04 50 V M 076 045 R 1 1
 740603 04 50 V F 076 046 R 2 1
 740603 04 51 M 079 047 L 1 1
 740603 04 51 M 075 043 R 1 1
 740603 04 52 F 074 044 L 1 1
 740603 04 53 M 076 044 R 1 1
 740603 04 53 F 077 046 R 1 1
 740603 04 53 M 076 045 R 1 1
 740603 04 53 F 075 043 L 2 1
 740603 04 53 F 074 043 L 1 1
 740603 04 53 F 076 044 L 1 1
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 740603 04 53 F 076 044 L 1 1
 740603 04 53 M 074 043 L 1 1
 740603 04 53 M 064 036 L 1 1
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 740603 04 53 F 073 043 L 2 1
 740603 04 54 M 075 043 L 1 1
 740603 04 54 M 072 042 R 1 1
 740603 04 54 M 080 048 R 1 1
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 740603 04 56 F 066 037 L 1 1
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 740603 04 58 M 084 037 R 1 1
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 740603 04 59 M 084 037 R 1 1
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 740603 04 60 M 076 044 L 1 1
 740603 04 60 M 073 045 R 1 1

DATE SDD T# V S LEN WID H E D

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 740607 04 42 V F 079 046 R 1 1
 740607 04 42 V M 075 043 L 1 1
 740607 04 42 V F 079 046 R 1 1
 740607 04 42 V F 077 049 L 1 1
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 740607 04 44 V F 081 050 L 1 1
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 740607 04 44 V F 080 050 R 1 1
 740607 04 45 V M 077 046 R 1 1
 740607 04 46 V M 079 046 R 1 1
 740607 04 48 V F 080 049 L 1 1
 740607 04 48 V F 084 050 L 1 1
 740607 04 49 V M 080 047 L 1 1
 740607 04 49 V F 077 046 R 1 1
 740607 04 50 V M 087 050 R 1 1
 740607 04 50 V F 077 046 L 1 1
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 740607 04 52 F 079 046 L 1 1
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 740607 04 53 F 073 043 R 1 1
 740607 04 53 M 076 044 R 1 1
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 740607 04 54 M 075 043 L 1 1
 740607 04 54 M 080 046 L 1 1
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 740607 04 54 F 071 043 L 1 1
 740607 04 54 F 080 047 R 1 1
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 740607 04 55 M 067 039 R 1 1
 740607 04 55 F 074 046 L 1 1
 740607 04 55 F 076 045 L 1 1
 740607 04 55 F 068 047 R 1 1
 740607 04 55 F 079 046 L 1 1
 740607 04 55 F 070 042 L 1 1
 740607 04 55 F 075 044 R 1 1
 740607 04 56 F 065 037 L 1 1
 740607 04 56 F 079 045 R 2 1 1
 740607 04 56 M 079 045 L 1 1
 740607 04 56 F 065 037 L 1 1

DATE SDD T# V S LEN WID H E D

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 740607 04 56 M 076 043 L 1 1
 740607 04 56 M 075 043 L 1 1
 740607 04 56 F 082 029 R 1 1
 740607 04 57 M 087 046 R 1 1
 740607 04 57 F 076 039 L 1 1
 740607 04 57 M 064 036 R 1 1
 740607 04 57 M 074 042 L 1 1
 740607 04 57 M 074 039 L 1 1
 740607 04 58 F 073 042 R 1 1
 740607 04 58 F 079 046 R 1 1
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 740607 04 58 M 074 042 R 1 1
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 740607 04 58 F 073 042 L 1 1
 740607 04 59 M 071 042 R 1 1
 740607 04 59 F 069 039 R 1 1
 740607 04 59 M 073 042 L 1 1
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 740607 04 60 F 063 036 L 1 1
 740607 04 60 F 063 036 R 1 1
 740607 04 60 F 075 044 R 1 1
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 740612 05 41 V M 081 049 L 1 1
 740612 05 42 V F 081 080 R 1 1
 740612 05 43 V M 079 047 L 1 1
 740612 05 43 V M 078 049 R 1 1
 740612 05 43 V M 087 048 R 1 1
 740612 05 43 V F 081 049 R 1 1
 740612 05 44 V M 081 049 R 1 1
 740612 05 44 V M 082 050 L 1 1
 740612 05 45 V M 080 050 L 1 1
 740612 05 45 V F 076 046 R 1 1
 740612 05 45 M 076 047 R 1 1
 740612 05 45 V F 075 043 L 1 1
 740612 05 45 V M 075 043 R 1 1
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LOBSTER DATA - SURFACE HAULED TRAPS

HOODS MOLE, MA, 1974

DATE SBD T# V S LEN WID H E D

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DATE SBD T# V S LEN WID H E D

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DATE SBD T# V S LEN WID H E D

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LOBSTER DATA - SURFACE HAULED TRAPS

HOODS MOLE, MA, 1974

DATE SBD T# V S LEN WID H E D

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DATE SBD T# V S LEN WID H E D

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DATE SBD T# V S LEN WID H E D

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LOBSTER DATA - SURFACE HAULED TRAPS
WOODS HOLE, MA, 1974

DATE SDD T# V S LEN WID H E D

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DATE SDD T# V S LEN WID H E D

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DATE SDD T# V S LEN WID H E D

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LOBSTER DATA - SURFACE HAULED TRAPS
WOODS HOLE, MA, 1974

DATE SDD T# V S LEN WID H E D

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DATE SDD T# V S LEN WID H E D

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DATE SDD T# V S LEN WID H E D

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740705 08 59 M 078 045 R
740705 08 60 M 079 045 R 1
740705 08 60 F 074 045 L 1
740705 08 60 M 078 042 L 1
740705 08 60 M 066 037 R 1
740705 08 60 M 066 038 L 1
740705 08 60 M 080 046 L 1
740705 08 60 M 066 039 L 1
740705 08 60 F 079 049 R 1
740705 08 60 M 067 038 L 1
740705 08 60 M 070 039 L 1
740705 08 60 M 072 040 R 1
740705 08 60 F 068 040 L
740705 08 60 M 070 042 R 1
740705 08 60 F 063 036 R 1
740705 08 60 F 065 036 R 1
740705 08 60 M 079 044 R 1
740705 08 60 M 084 049 L 1
740705 08 60 M 069 030 L 1
740705 08 60 M 086 050 L 1
740705 08 60 M 071 041 R 1
740705 08 60 M 070 041 L
740705 08 60 F 065
740705 08 60 F 077 045 R
740705 08 60 M 075 043 L
740705 08 60 M 066 037 R
740705 08 60 F 073 042 L
740705 08 60 M 076 043 R
740710 13 42 V 078 046 L 1
740710 13 42 V 079 049 L
740710 13 42 V 077 046 L
740710 13 42 V 074 045 L
740710 13 42 V 078 047 R
740710 13 46 V 079 048 R 1
740710 13 47 V 086 055 L 1
740710 13 47 V 078 048 R 1
740710 13 47 V 085 050 R
740710 13 48 V 080 046 L
740710 13 49 V 081 047 R 1
740710 13 49 V 081 048 L 1
740710 13 49 V 085 051 L 1
740710 13 49 V 080 051 L
740710 13 49 V 080 048 L 1
740710 13 50 V 078 046 R 1
740710 13 50 V 080 049
740710 13 50 V 080 048
740710 13 50 V 078 049 R
740710 08 52 F 066 038 L 1

LOBSTER DATA - SURFACE HAULED TRAPS

MOOSE HOLE, MA, 1974

DATE SBD T# V S LEN WID H E D

740710 05 52 M 070 043 L 1
740710 05 52 F 074 044 L 1
740710 05 52 F 074 046 L 1
740710 05 52 F 082 051 L 1
740710 05 52 M 075 046 R 1
740710 05 52 F 069 042 L 1
740710 05 52 M 080 047 R 1
740710 05 52 M 074 042 R 1
740710 05 52 F 071 049 R 1
740710 05 52 F 078 048 R 1
740710 05 53 M 074 044 L 1
740710 05 53 F 087 051 L 1
740710 05 53 F 072 044 L 1
740710 05 53 F 061 038 R 1
740710 05 53 M 068 039 L 1
740710 05 53 F 073 044 R 1
740710 05 53 M 073 042 R 1
740710 05 53 F 077 045 R 1
740710 05 53 M 089 049 R 1
740710 05 53 F 073 043 R 1
740710 05 53 M 072 042 R 1
740710 05 53 M 075 045 L 1
740710 05 53 M 078 046 R 1
740710 05 53 F 079 048 R 1
740710 05 53 F 071 041 R 1
740710 05 54 F 070 039 R 1
740710 05 54 F 082 049 L 1
740710 05 54 F 075 044 R 1
740710 05 54 M 080 047 R 1
740710 05 54 M 088 053 R 1
740710 05 54 F 076 047 L 1
740710 05 54 F 070 043 R 1
740710 05 55 M 089 049 R 1
740710 05 55 M 070 041 R 1
740710 05 55 M 086 052 R 1
740710 05 55 M 077 043 R 1
740710 05 55 F 081 051 L 1
740710 05 55 F 066 044 R 1
740710 05 55 M 074 044 R 1
740710 05 55 M 080 048 L 1
740710 05 55 F 072 042 L 1
740710 05 55 M 074 044 L 1
740710 05 55 F 072 042 L 1
740710 05 55 F 072 042 L 1
740710 05 55 F 085 052 R 1
740710 05 55 F 073 045 R 1
740710 05 55 M 089 053 L 1
740710 05 55 F 072 042 L 1
740710 05 55 F 082 050 L 1
740710 05 57 F 069 R 1
740710 05 57 M 023 043 R 1

DATE SBD T# V S LEN WID H E D

740710 05 57 M 059 039 L 1
740710 05 58 M 087 052 L 1
740710 05 58 F 075 045 R 1
740710 05 58 F 074 044 L 1
740710 05 58 F 072 042 L 1
740710 05 58 F 082 048 R 1
740710 05 58 F 069 039 R 1
740710 05 58 M 067 039 L 1
740710 05 58 M 079 049 R 1
740710 05 58 F 072 042 R 1
740710 05 58 F 075 045 L 1
740710 05 58 M 083 047 R 1
740710 05 58 F 072 042 L 1
740710 05 59 M 077 045 R 1
740710 05 59 M 068 039 L 1
740710 05 59 M 073 033 R 1
740710 05 59 F 079 048 L 1
740710 05 60 M 074 043 R 1
740710 05 60 F 083 044 R 1
740710 05 60 F 081 050 R 1
740710 05 60 M 074 043 L 1
740710 05 60 F 063 036 L 1
740710 05 60 M 070 036 L 1
740710 05 60 F 077 046 R 1
740710 05 60 F 071 041 R 1
740710 05 60 M 072 041 L 1
740710 05 60 M 072 042 L 1
740710 05 60 M 085 046 L 1
740710 05 60 F 080 048 R 1
740710 05 60 M 070 040 R 1
740713 13 42 V F 078 049 R 1
740713 13 42 V F 080 049 L 1
740713 13 43 V M 080 047 R 1
740713 13 43 V M 090 055 R 1
740713 13 43 V F 081 050 L 1
740713 13 43 V M 078 047 L 1
740713 13 43 V F 086 052 L 1
740713 13 44 V F 081 051 R 1
740713 13 44 V M 084 050 R 1
740713 13 45 V M 080 047 R 1
740713 13 45 V F 083 052 L 1
740713 13 45 V M 084 051 R 1
740714 06 41 V F 081 051 R 1
740716 06 42 V F 076 047 L 1
740716 06 42 V F 072 045 R 1
740716 06 42 V F 075 046 R 1
740716 06 42 V F 076 046 R 1
740716 06 42 V F 079 049 R 1
740716 06 42 V F 081 051 L 1
740716 06 42 V F 074 046 L 1
740716 06 42 V F 081 050 R 1

DATE SBD T# V S LEN WID H E D

740716 06 44 V F 075 047 L 1
740716 06 44 V F 087 053 R 1
740716 06 44 V F 079 049 R 1
740716 06 45 V M 080 049 R 1
740716 06 46 V F 076 046 R 1
740716 06 46 V F 084 051 R 1
740716 06 46 V F 079 048 L 1
740716 06 47 V F 081 050 L 1
740716 06 48 V F 077 047 L 1
740716 06 48 V F 078 048 R 1
740716 06 48 V F 079 049 L 1
740716 06 49 V M 080 047 R 1
740716 06 49 V F 082 051 L 1
740716 06 49 V F 080 046 L 1
740716 06 49 V F 082 050 L 1
740716 06 52 F 083 049 R 1
740716 06 52 M 066 039 R 1
740716 06 52 F 066 041 L 1
740716 06 52 M 079 041 L 1
740716 06 52 F 066 041 R 1
740716 06 52 M 074 043 L 1
740716 06 52 F 066 039 L 1
740716 06 52 M 080 049 L 1
740716 06 52 F 071 048 L 1
740716 06 52 M 086 053 R 1
740716 06 52 M 065 037 L 1
740716 06 52 M 064 036 L 1
740716 06 52 F 068 041 L 1
740716 06 53 M 071 044 R 1
740716 06 53 F 067 041 R 1
740716 06 53 F 077 044 R 1
740716 06 53 M 079 045 L 1
740716 06 53 F 070 042 R 1
740716 06 53 M 072 042 R 1
740716 06 53 F 074 046 R 1
740716 06 53 M 079 045 L 1
740716 06 53 F 068 040 R 1
740716 06 53 F 071 044 R 1
740716 06 53 F 071 042 R 1
740716 06 54 M 072 042 L 1
740716 06 54 F 073 044 R 1
740716 06 54 M 072 043 R 1
740716 06 54 F 086 049 L 1
740716 06 54 F 082 049 R 1
740716 06 54 F 072 043 R 1
740716 06 55 F 069 049 R 1
740716 06 55 F 081 049 L 1
740716 06 55 F 075 046 L 1
740716 06 55 M 075 045 L 1
740716 06 55 F 079 046 R 1
740716 06 55 F 084 052 L 1

LOBSTER DATA - SURFACE HAULED TRAPS

MOOSE HOLE, MA, 1974

DATE SBD T# V S LEN WID H E D

740716 06 55 M 079 046 R 1
740716 06 55 F 074 044 L 1
740716 06 55 F 065 048 R 1
740716 06 55 M 075 043 R 1
740716 06 55 M 075 043 R 1
740716 06 55 M 071 042 R 1
740716 06 55 F 076 047 R 1
740716 06 55 F 087 055 R 1
740716 06 55 M 086 052 L 1
740716 06 55 F 071 042 L 1
740716 06 55 F 072 044 R 1
740716 06 55 F 076 044 L 1
740716 06 55 F 077 049 R 1
740716 06 57 M 071 044 L 1
740716 06 57 F 078 049 L 1
740716 06 57 M 067 039 L 1
740716 06 57 F 073 045 L 1
740716 06 57 M 076 045 L 1
740716 06 57 M 070 041 R 1
740716 06 57 M 070 041 R 1
740716 06 58 F 083 050 L 1
740716 06 58 M 074 044 R 1
740716 06 58 M 074 041 R 1
740716 06 58 F 075 045 R 1
740716 06 58 M 081 050 R 1
740716 06 59 M 064 038 L 1
740716 06 59 F 065 048 R 1
740716 06 59 M 079 045 L 1
740716 06 59 F 081 050 L 1
740716 06 59 M 065 039 L 1
740716 06 60 F 081 050 L 1
740716 06 60 M 074 046 R 1
740716 06 60 M 069 040 R 1
740716 06 60 M 064 039 R 1
740716 06 60 M 064 039 L 1
740716 06 60 F 079 046 R 1
740716 06 60 F 077 047 R 1
740716 06 60 F 082 051 L 1
740716 06 60 F 083 050 L 1
740716 06 60 F 067 040 L 1
740716 06 60 F 064 040 R 1
740716 06 60 F 060 039 R 1
740716 06 60 M 068 042 L 1
740716 06 60 M 065 039 L 1
740716 06 60 F 069 041 R 1
740716 06 60 F 074 044 L 1
740716 06 60 M 070 041 L 1
740716 06 60 M 072 042 L 1
740716 06 60 M 073 042 R 1
740716 06 60 F 072 044 L 1
740722 06 42 V F 079 047 R 1

DATE SBD T# V S LEN WID H E D

740722 06 43 V F 080 049 L 1
740722 06 43 V F 082 050 R 1
740722 06 43 V M 075 045 R 1
740722 06 43 V F 075 046 L 1
740722 06 44 V F 077 045 R 1
740722 06 44 V F 077 045 R 1
740722 06 44 V F 079 049 R 1
740722 06 44 V F 079 049 R 1
740722 06 44 V F 080 050 L 1
740722 06 45 V F 078 047 R 1
740722 06 45 V F 079 049 L 1
740722 06 45 V F 079 049 R 1
740722 06 45 V F 081 050 L 1
740722 06 45 V M 075 045 L 1
740722 06 45 V F 080 049 R 1
740722 06 47 V F 076 049 R 1
740722 06 47 V F 081 050 R 1
740722 06 48 V F 077 047 L 1
740722 06 49 V F 075 047 L 1
740722 06 50 V M 080 049 R 1
740722 06 50 V F 085 052 L 1
740722 06 52 F 070 042 L 1
740722 06 52 F 070 040 L 1
740722 06 52 M 077 045 R 1
740722 06 52 F 078 049 R 1
740722 06 52 F 077 047 L 1
740722 06 53 F 078 048 L 1
740722 06 53 M 070 041 R 1
740722 06 53 F 075 045 L 1
740722 06 53 M 075 045 R 1
740722 06 53 F 072 044 L 1
740722 06 53 M 075 044 R 1
740722 06 53 M 079 046 R 1
740722 06 54 M 091 056 R 1
740722 06 54 F 077 047 R 1
740722 06 54 M 089 052 L 1
740722 06 54 F 087 054 R 1
740722 06 54 M 077 046 R 1
740722 06 54 F 078 046 R 1
740722 06 54 M 075 046 R 1
740722 06 54 M 079 045 R 1
740722 06 54 F 072 044 L 1
740722 06 55 M 073 043 R 1
740722 06 55 M 071 042 L 1
740722 06 55 M 080 047 L 1
740722 06 55 F 069 043 R 1
740722 06 55 M 069 039 L 1
740722 06 55 M 071 040 R 1
740722 06 55 F 081 049 R 1

DATE SBD T# V S LEN WID H E D

740722 06 55 F 073 043 L 1
740722 06 55 F 079 049 R 1
740722 06 55 F 079 049 R 1
740722 06 57 F 070 042 R 1
740722 06 57 F 079 050 L 1
740722 06 58 F 079 049 R 1
740722 06 58 M 074 046 L 1
740722 06 58 F 077 046 R 1
740722 06 59 M 076 047 R 1
740722 06 59 M 079 048 R 1
740722 06 59 F 086 040 R 1
740722 06 59 M 074 045 L 1
740722 06 59 M 075 045 L 1
740722 06 60 F 071 044 R 1
740722 06 60 M 076 045 L 1
740722 06 60 M 067 040 L 1
740722 06 60 F 074 045 L 1
740722 06 60 M 069 040 R 1
740722 06 60 F 075 046 R 1
740722 06 60 M 073 042 L 1
740722 06 60 M 076 046 R 1
740722 06 60 F 069 042 L 1
740722 06 60 F 082 051 L 1
740722 06 60 F 074 042 L 1
740722 06 60 M 066 039 L 1
740722 06 60 M 077 045 L 1
740722 06 60 F 065 039 R 1
740722 06 60 F 075 046 R 1
740722 06 60 F 080 051 R 1
740722 06 60 M 077 045 L 1
740730 08 42 V F 082 056 L 1
740730 08 42 V F 078 049 R 1
740730 08 43 V F 080 048 R 1
740730 08 43 V F 085 054 L 1
740730 08 43 V F 074 047 R 1
740730 08 44 V F 081 048 L 1
740730 08 44 V M 079 045 R 1
740730 08 45 V M 077 046 R 1
740730 08 47 V F 080 048 L 1
740730 08 47 V F 080 047 L 1
740730 08 48 V F 078 045 R 1
740730 08 48 V F 078 048 L 1
740730 08 48 V F 080 050 L 1
740730 08 48 V F 078 048 R 1
740730 08 48 V M 081 051 L 1
740730 08 49 V F 080 049 R 1
740730 08 50 V F 069 042 R 1
740730 08 51 F 083 053 L 1
740730 08 52 F 075 044 L 1

LOBSTER DATA - SURFACE HAULED TRAPS

LOBSTER DATA - SURFACE HAULS
WOODS HOLE, MA. 1974

DATE SBD T# V S LEN WID H E D

740730	08 52	F 073 045 R	1
740730	08 52	F 073 040 R	1
740730	08 52	F 068 040 R	1
740730	08 52	F 067 040 R	1
740730	08 52	F 077 048 R	1
740730	08 52	M 069 040 R	1
740730	08 52	M 068 040 R	1
740730	08 52	M 067 040 R	1
740730	08 53	M 074 045 L	1
740730	08 53	M 071 042 R	1
740730	08 53	M 069 041 L	1
740730	08 53	F 069 041 R	1
740730	08 53	F 068 039 R	1
740730	08 53	F 070 041 R	1
740730	08 53	F 077 047 R	1
740730	08 54	F 084 052 R	1
740730	08 54	M 073 044 L	1
740730	08 54	M 072 044 L	1
740730	08 54	M 078 049 L	1
740730	08 54	M 079 045 L	1
740730	08 55	M 078 044 R	1
740730	08 55	F 068 040 R	1
740730	08 55	F 074 047 R	1
740730	08 55	F 079 048 L	1
740730	08 55	M 075 043 R	1
740730	08 55	F 087 054 L	1
740730	08 55	M 077 047 R	1
740730	08 57	F 067 043 R	1
740730	08 57	M 072 043 L	1
740730	08 57	M 077 046 R	1
740730	08 57	F 078 048 L	1
740730	08 57	F 086 051 R	1
740730	08 57	F 087 048 R	1
740730	08 57	M 072 042 R	1
740730	08 57	M 073 044 R	1
740730	08 57	M 076 046 L	1
740730	08 57	M 075 043 L	1
740730	08 58	M 085 053 R	1
740730	08 58	M 084 053 R	1
740730	08 58	M 080 046 R	1
740730	08 58	M 076 043 L	1
740730	08 58	M 077 044 R	1
740730	08 58	F 087 048 R	1
740730	08 58	F 087 044 R	1
740730	08 58	F 085 050 R	1
740730	08 58	F 083 049 R	1
740730	08 59	M 076 046 R	1
740730	08 59	F 077 048 R	1
740730	08 59	F 071 041 R	1
740730	08 59	F 076 044 L	1
740730	08 59	F 075 044 L	1

DATE SBD T# V S LEN MID H E D

7a0730	08 59	M	073 043	L
7a0730	08 60	M	073 043	R
7a0730	08 60	F	080 050	L
7a0730	08 60	F	080 050	R
7a0805	06 6n	F	080 050	L
7a0805	06 60	M	087 040	R
7a0805	06 60	F	081 034	L
7a0805	06 60	M	081 034	R
7a0805	06 60	M	086 055	L
7a0805	06 60	M	086 037	R
7a0805	06 60	M	084 033	R
7a0805	06 60	F	085	
7a0805	06 60	F	085	
7a0805	06 60	F	084 051	R
7a0805	06 60	F	069 039	L
7a0805	06 60	F	083 054	
7a0805	06 60	F	072 045	L
7a0805	06 60	F	066 040	L
7a0805	06 60	F	062 036	L
7a0806	07 42	V	075 047	R
7a0806	07 43	V	075 047	R
7a0806	07 44	V	081 050	L
7a0806	07 45	V	075 049	R
7a0806	07 45	V	080 049	R
7a0806	07 45	V	076 046	L
7a0806	07 45	V	085 054	L
7a0806	07 47	V	081 050	L
7a0806	07 47	V	081 050	L
7a0806	07 47	V	079 051	L
7a0806	07 47	V	081 051	L
7a0806	07 48	V	079 049	L
7a0806	07 48	V	083 050	R
7a0806	07 48	V	083 054	R
7a0806	07 49	V	077 047	R
7a0806	07 49	V	077 047	L
7a0806	07 51-	M	080 050	L
7a0806	07 52	M	080 050	L
7a0806	07 52	M	071 044	R
7a0806	07 52	M	075 047	R
7a0806	07 52	M	073 043	L
7a0806	07 52	F	068 040	R
7a0806	07 52	F	073 045	R
7a0806	07 53	M	084 052	R
7a0806	07 53	F	070 043	L
7a0806	07 53	F	081 050	L
7a0806	07 53	F	071 044	R
7a0806	07 54	F	075 046	L
7a0806	07 54	F	077 049	R

DATE SBD TH V S LEN WID H E D

7408006	07 54	F 079 049	
7408006	07 55	M 079 049	R
7408006	07 55	F 083 042	L
7408006	07 55	M 081 050	R
7408006	07 55	M 075 044	L
7408006	07 55	M 073 043	L
7408006	07 55	F 071 041	R
7408006	06 57	F 075 046	R
7408006	06 57	F 075 046	R
7408008	06 57	F 078 047	R
7408008	06 57	M 077 048	L
7408008	06 57	F 077 048	L
7408008	06 57	F 070 040	R
7408008	06 57	F 066 040	L
7408008	06 57	M 076 043	R
7408008	06 57	M 085 039	R
7408008	06 57	M 072 041	R
7408008	06 57	F 077 048	R
7408008	06 57	F 071 042	R
7408008	06 58	F 079 047	R
7408008	06 58	F 076 045	R
7408008	06 58	F 077 046	R
7408008	06 58	F 077 046	R
7408008	06 58	F 072 044	R
7408008	06 58	F 077 047	R
7408008	06 58	F 075 046	R
7408008	06 58	F 074 045	R
7408012	06 42	V F 083 050	L
7408012	06 42	V F 083 050	L
7408012	06 42	V M 079 045	L
7408012	06 42	V F 079 045	L
7408012	06 42	V F 079 045	L
7408012	06 42	V F 079 045	L
7408012	06 44	V F 079 050	L
7408012	06 44	V F 076 045	L
7408012	06 44	V F 092 057	L
7408012	06 44	V M 080 046	L
7408012	06 44	V F 079 045	L
7408012	06 45	V F 074 045	R
7408012	06 45	V F 080 048	R
7408012	06 45	V F 077 047	R
7408012	06 45	V F 080 049	R
7408012	06 45	V F 080 049	R
7408012	06 45	V F 084 051	L
7408012	06 45	V F 080 049	R
7408012	06 45	V F 078 047	R
7408012	06 46	V F 080 049	L
7408012	06 46	V F 083 045	L
7408012	06 46	V F 083 050	L
7408012	06 47	V F 077 047	R

LOBSTER DATA - SURFACE HAULED TRAPS

LOBSTER DATA - SURFACE MA
WOODS HOLE, MA: 1974

DATE SBD TH V S LEN WID H E D

740812	06	47	V	M	078	046	R	1
740812	06	47	V	M	078	045	R	
740812	06	47	V	M	078	044	R	
740812	06	47	V	M	082	050	R	
740812	06	48	V	M	077	045	R	1
740812	06	48	V	M	077	047	R	
740812	06	48	V	F	095	055	R	
740812	06	48	V	M	077	046	L	2
740812	06	48	V	M	077	046	L	
740812	06	49	V	M	078	046	L	
740812	06	49	V	M	076	045	R	
740812	06	50	V	F	084	050	R	
740812	06	52	F	080	045	R		
740812	06	52	F	M	072	041	R	
740812	06	52	M	M	075	043	R	
740812	06	52	M	M	071	042	R	
740812	06	52	F	F	081	049	R	
740812	06	52	F	F	081	044	R	
740812	06	52	F	F	087	054	R	
740812	06	52	F	F	077	045	L	
740812	06	52	M	M	069	039	L	
740812	06	52	M	M	072	042		
740812	06	52	F	F	079	044		
740812	06	52	F	F	073	044	R	
740812	06	53	F	071	043	L		
740812	06	53	F	079	049	L		
740812	06	53	F	084	039	L		
740812	06	55	F	075	045	R		
740812	06	55	F	069	040	R		
740812	06	55	F	084	051	R		
740812	06	55	F	072	044	R		
740812	06	57	F	080	047	R		
740812	06	57	F	077	045	R		2
740812	06	57	F	079	047	R		
740812	06	57	F	079	047	R		
740812	06	58	M	076	044	L		
740812	06	58	M	079	047	R		
740812	06	58	M	079	043	R		
740812	06	58	M	079	043	R		
740812	06	58	M	079	043	R		
740812	06	58	F	072	043	R	2	
740812	06	58	M	080	047	R		
740812	06	58	F	076	046	L	2	
740812	06	59	F	080	046	R		
740812	06	59	F	086	038	R		
740812	06	59	F	080	047	L		
740812	06	59	M	076	045	R		
740812	06	59	F	078	046	L		
740812	06	59	F	067	035	R		
740812	06	59	F	067	039	L		
740812	06	59	F	074	042	R		

DATE SBD TO V S LEN WID H E D

7A0812	06 59	F	074	043	R	
7A0812	06 59	F	086	043	R	
7A0812	06 59	F	081	043	R	1
7A0812	06 60	M	089	053	R	1
7A0812	06 60	M	064	036	L	1
7A0812	06 60	M	079	043	R	1
7A0812	06 60	M	070	040	R	
7A0812	06 60	F	080	040	R	
7A0812	06 60	F	071	040	L	
7A0812	06 60	F	075	042	R	
7A0812	06 60	M	073	042	L	
7A0813	07 42	V	F	077	042	
7A0813	07 43	V	F	081	041	R
7A0813	07 43	V	F	081	049	R
7A0813	07 44	V	F	074	046	L
7A0813	07 44	V	F	076	048	L
7A0813	07 45	V	F	075	046	L
7A0813	07 45	V	M	075	046	L
7A0813	07 45	V	M	076	045	L
7A0813	07 45	V	M	080	045	L
7A0813	07 48	V	F	080	051	L
7A0813	07 48	V	F	080	051	L
7A0813	07 49	V	F	086	053	L
7A0813	07 49	V	F	077	047	L
7A0813	07 49	V	F	077	049	L
7A0813	07 50	V	F	082	052	L
7A0813	07 50	V	F	082	052	L
7A0813	07 50	V	F	078	046	R
7A0813	07 52	F	090	054	L	
7A0813	07 52	F	078	045	L	
7A0813	07 52	F	080	045	L	1
7A0813	07 52	F	080	045	L	1
7A0813	07 52	M	078	046	R	
7A0813	07 52	M	071	041	R	
7A0813	07 52	M	076	044	R	
7A0813	07 52	F	073	043	L	
7A0813	07 52	F	073	043	L	
7A0813	07 52	F	070	023	R	
7A0813	07 52	F	075	043	R	1
7A0813	07 52	F	079	047	R	1
7A0813	07 52	F	077	045	L	
7A0813	07 53	M	069	041	L	
7A0813	07 53	M	069	041	L	
7A0813	07 53	M	076	046	L	
7A0813	07 53	F	065	037	L	
7A0813	07 53	F	072	042	L	
7A0813	07 53	F	072	042	L	1
7A0813	07 53	M	069	039	L	
7A0813	07 54	F	072	042	L	

DATE SDD T# V S LEN WID H E D

740819	07 34	F 086 052	R 1
740819	07 54	F 086 052	R 1
740819	07 54	M 075 045	R 1
740819	07 54	F 074 046	R 1
740819	07 55	F 075 045	R 1
740819	07 55	F 075 045	R 1
740819	07 55	F 075 045	R 1
740819	07 55	F 075 045	R 1
740819	07 55	F 077 046	L 1
740819	07 55	F 077 046	L 1
740819	07 58	M 079 045	R 1
740819	07 58	M 079 045	R 1
740819	07 58	M 077 046	R 1
740819	07 58	M 077 046	R 1
740819	07 58	M 075 042	R 1
740819	07 58	F 086 050	R 1
740819	07 58	M 077 047	R 1
740819	07 58	M 077 047	R 1
740819	07 58	M 081 050	R 1
740819	07 58	F 072 045	R 1
740819	07 58	M 077 044	R 1
740819	07 59	M 072 041	R 1
740819	07 59	M 072 041	R 1
740819	07 59	F 068 044	R 1
740819	07 59	F 071 043	R 1
740819	07 59	F 070 041	R 1
740819	07 59	F 070 041	R 1
740819	07 59	M 075 045	R 1
740819	07 59	F 062 037	R 1
740819	07 59	F 079 045	L 1
740819	07 59	M 082 047	L 1
740819	07 59	M 082 047	L 1
740819	07 59	M 086 036	R 1
740819	07 60	M 073 044	R 1
740819	07 60	F 089 033	R 1
740819	07 60	M 077 044	R 1
740819	07 60	M 077 044	R 1
740819	07 60	F 083 044	R 1
740819	07 60	F 072 043	R 1
740819	07 60	F 072 043	R 1
740823	04 42	M 074 045	R 1
740823	04 42	M 075 045	R 1
740823	04 42	M 076 045	R 1
740823	04 42	M 076 045	R 1
740823	04 43	F 075 046	L 1
740823	04 43	M 078 046	L 1
740823	04 44	F 078 046	L 1
740823	04 44	F 073 046	L 1
740823	04 45	F 076 047	R 1
740823	04 45	M 078 047	R 1

LOBSTER DATA - SURFACE HAULED TRAPS

WOBBS HOLE, MA, 1974

DATE SBD T# V S LEN WID H E D

740823 04 46 V F 084 052 R
740823 04 48 V F 082 048 L 1 1
740823 04 48 V F 079 047 R
740823 04 48 V F 080 048 R
740823 04 49 V F 076 047 L 1
740823 04 49 V F 079 048 R 1 1
740823 04 49 V F 076 047 R 1
740823 04 50 V F 078 046 R
740823 04 51 F 070 042 R 1
740823 04 52 F 072 044 R 1
740823 04 52 M 074 045 R 1
740823 04 52 F 074 048 L 1 1
740823 04 52 M 075 042 L 1
740823 04 52 F 080 051 L 1
740823 04 52 M 073 043 R 1
740823 04 52 F 078 049 R 1
740823 04 52 F 077 047 L 1 1
740823 04 52 F 078 047 L 1 1
740823 04 52 F 073 044 R 1 1
740823 04 52 M 072 043 R 1
740823 04 52 F 085 053 R
740823 04 52 F 082 052 R
740823 04 52 F 067 042 L
740823 04 52 M 079 045 L
740823 04 52 F 078 048 R
740823 04 52 F 075 044 R
740823 04 52 F 079 047 R
740823 04 53 F 084 051 R 1
740823 04 53 F 079 048 L
740823 04 54 M 079 047 R
740823 04 54 F 079 048 R 1
740823 04 59 M 079 048 R 1
740823 04 59 F 073 044 R 1
740823 04 59 M 069 041 R 1
740823 04 59 M 067 039 R 1
740823 04 59 F 067 039 R 1
740823 04 59 M 069 039 L 1
740823 04 59 M 067 041 L 1
740823 04 59 M 080 046 R
740823 04 59 M 068 039 L
740823 04 59 M 078 045 L
740823 04 59 F 080 048 R
740823 04 60 M 079 047 R 1
740823 04 60 F 068 040 L 1
740823 04 60 F 066 038 L 1
740823 04 60 F 077 047 R 1
740823 04 60 M 067 039 L 1
740823 04 60 M 070 041 R 1
740823 04 60 M 066 037 L 1
740823 04 60 M 074 047 R 1
740823 04 60 M 062 035 L 1

DATE SBD T# V S LEN WID H E D

740823 04 60 M 063 036 R 1
740823 04 60 F 059 035 R 1
740823 04 60 F 064 038 L 1
740823 04 60 M 063 038 R
740823 04 60 M 071 044 R

APPENDIX B

"Lost" trap inventory

Key to tables

- O[□]: Injured in trap
- D: Dead
- M: Missing
- E: Escaped (later recaptured)
- RR: Right (claw) regenerate
- LR: Left (claw) regenerate
- RM: Right (claw) missing
- LM: Left (claw) missing
- Cara: Carapace damaged
- URO: Uropods damaged
- M legs: Missing legs

"Lost" Trap Inventory — First Phase

TRAP NUMBER	Trapper	Sex	1 FEB	9 FEB	13 FEB	26 FEB	9 MARCH	15 MARCH	20 MARCH	29 MARCH	3 APRIL	13 APRIL	18 APRIL	24 APRIL	7 MAY	14 MAY	END 22 MAY	REMARKS
11	77	M																I-LM
	74	M																
	81	F																RR, I-Cara, M-Legs
	84	M																I-LM
	85	F																I-M Legs
	80	F																I-URO, M Legs
	83	M																LR
12	77	M																
	79	F																
13	75	M																
	79	F																
14	75	M																I-M Legs
	79	F																I-M Legs
	77	F																
	70	M																I-RM, M Legs
	74	M																I-M Legs
	64	F																
15	74	M																I-Cara, M Legs
	80	M																RR, I-LM
	81	F																
16	71	F																RR
	75	M																
17	73	M																
	73	M																
	69	M																LR
	68	M																
	66	F																
18	74	M																
	82	M																
	73	F																
19	79	F																
	76	F																
20	78	F																
	80	F																

"Lost" Trap Inventory — First Phase

TRAP NUMBER	(mm)	1 FEB	9 FEB	13 FEB	26 FEB	9 MARCH	15 MARCH	20 MARCH	29 MARCH	3 APRIL	13 APRIL	19 APRIL	24 APRIL	30 APRIL	7 MAY	14 MAY	END 22 MAY	REMARKS
73	F																	RR, I-URO, LM
64	F																	
77	M																	
77	M																	
80	M																	
69	F																	
74	M																	
67	M																	
76	M																	
73	M																	I-URO
65	M																	
68	F																	
78	M																	
79	M																	
66	F																	
59	M																	
66	F																	
71	M																	
75	M																	
74	M																	
86	M																	
74	M																	
27	VAC																	
77	M																	
78	M																	
89	F																	
72	F																	
77	M																	
78	F																	
66	F																	

"Lost" Trap Inventory — Second Phase

TRAP NUMBER	(mm)	24 MAY	1 JUNE	8 JUNE	12 JUNE	20 JUNE	28 JUNE	6 JULY	20 JULY	16 JULY	24 JULY	3 AUGUST	9 AUGUST	21 AUGUST	END 29 AUGUST	REMARKS
72	F															
78	M															
76	M															
73	F															
78	M															
77	M															
79	M															
89	M															
66	F															
78	F															
81	F															
81	M															
86	M															
76	F															
75	F															
78	M															
77	M															
69	M															
77	F															
89	M															
74	M															
63	F															
71	M															
76	M															
75	M															
72	M															
78	F															
79	F															
76	F															
75	M															
75	F															
72	M															
74	F															
78	F															
76	F															
76	M															
70	M															
73	M															
91	M															
81	M															
67	M															

"Lost" Trap Inventory — Second Phase

Trap Number	Lower Size	24 MAY	1 JUNE	8 JUNE	12 JUNE	20 JUNE	29 JUNE	6 JULY	10 JULY	16 JULY	24 JULY	3 AUGUST	8 AUGUST	21 AUGUST	END 24 AUGUST	REMARKS
19	63 M															RR
	75 M															LR
	70 F															
	73 F															
	69 M															
	68 F															I-LM, RM
	73 F															
	67 F															
	76 M															
	86 M															
20	81 F															RM
	92 M															
	76 F															
	69 F															I-LM
	60 F															
	76 M															
	75 M															
	75 F															I-RM
	74 F															
	78 M															I-M Legs
21	87 F															I-Uro
	72 F															LM
	80 M															LR
	80 F															I-LM, RM, M Legs
	76 M															
	68 M															
	70 F															I-Uro
	79 F															
	84 M															
	82 M															
22	62 F															
	76 F															
	73 M															RM
	81 M															I-LM, RM, M Leg
	74 M															
	85 F															I-LM, M Legs
	77 F															RM
	75 F															
	77 F															
	75 M															I-Toil
23	74 M															
	71 M															RM
	92 M															I-M Legs
	68 F															
	74 F															

"Lost" Trap Inventory — Second Phase

Trap Number	Lower Size	24 MAY	1 JUNE	8 JUNE	12 JUNE	20 JUNE	29 JUNE	6 JULY	10 JULY	16 JULY	24 JULY	3 AUGUST	8 AUGUST	21 AUGUST	END 24 AUGUST	REMARKS
24	73 F															I-LM, M Leg
	66 F															
	72 M															LM
	68 F															I-RM
	71 M															LM, RM
	63 F															RM
	86 F															
	67 M															I-M Leg
	91 F															I-M Leg
	80 F															RR; I-LM
	74 M															RM
	71 M															LM, RM; I-M All Legs
	90 F															
	72 F															LR; I-Uro
	77 M															
	92 F															I-LM
	78 M															
	75 M															RM

"Lost" Trap Inventory — Second Phase

Trap Number	Lower Size	Sex	24 May	1 June	8 June	12 June	20 June	28 June	6 July	10 July	16 July	24 July	3 August	8 August	21 August	29 August	REMARKS
75	F							M									
61	F																
79	F																I-Tail
78	M																I-Tail
70	M																I-M Leg
74	M																RR, LR, I-LM, RM, M All Legs
69	M																
78	M																LM
62	M																
69	F																I-Tail
84	M																RM
83	M																LM, RR
25	80	M															
71	M																
74	M																
26	71	M															LM, RM
76	M																
76	F																I-LM, RM
82	F																
67	M																
27	76	M															
78	M																
66	M																
69	M																LM
63	F																
70	F																
78	M																
28	79	M															I-RM
76	F																RR
75	M																I-LM
64	M																
85	M																LR
29	71	M															
80	F																LM, 6 M Legs
72	M																
67	M																
73	F																
30	80	F															
74	M																LM, RM

"Lost" Trap Inventory — Third Phase

Trap Number	Lower Size	Sex	9 May	16 May	21 May	22 May	23 May	30 May	31 May	4 June	13 June	18 June	19 June	28 June	9 July	2 August	REMARKS
61			EMPTY														
73	M																RM
70	F																I-RM, LM
71	F																LD
72	M																
70	M																I-LM
75	M																
76	F																Eggs
71	F																
73	F																
69	M																RR
80	M																I-RM
72	M																
71	M																
75	M																
74	M																
76	M																
78	F																
76	M																
62	F																
51	M																
104	F																
62	78	M															

TRAP RAIDED

Note - 2 August - Eight new Lobsters in Trap 62

SIZE	SEX
I-LD	70 F
	74 F
RR	75 F
I-LM	84 F
LD	81 M
	75 M
	59 M
	71 M

"Lost" Trap Inventory — Third Phase

Trap Number	Location	Size	9 May	16 May	21 May	22 May	23 May	30 May	31 May	4 June	13 June	18 June	19 June	26 June	9 July	2 August	REMARKS
Observation Days																	
63	77 M																
	75 M																
	83 F																1 - RM, LM
	79 M																
	78 M																RM
	80 M																1 - RM, Tail M
	82 M																
Observation Days																	
64	75 F																Eggar
	78 M																
	81 M																
	80 F																
	84 M																
	78 M																
	77 M																RM
Observation Days																	
65	78 M																RM
	88 M																LD
	74 F																RR, Eggar, 1 - LM, RM
	82 M																RM
Observation Days																	
66	65 F																
	96 M																
	75 F																
	80 M																1 - URD
	85 M																
	89 M																
	80 M																
Observation Days																	
67	78 M																
	76 F																
	91 M																Eggar
	58 M																LM, 1 - all legs M
	90 M																RM
	85 M																1 - LM
	79 M																1 - URD
Observation Days																	
68	85 F																
	75 M																
	85 M																1 - LM
	73 M																
	78 M																
	80 M																
	90 M																
Observation Days																	
69	79 F																
	86 F																
	89 M																
	83 F																
	79 F																
	81 M																
	83 M																
Observation Days																	
70	78 F																
	83 M																
	81 F																
	80 F																
	84 F																
	82 F																
	77 F																
Observation Days																	
70	78 F																
	83 M																
	81 F																

"Lost" Trap Inventory — Third Phase

TRAP NUMBER	DATE	TIME	LOCATION	STATUS	REMARKS
71	68 M			EMPTY	
71	57 M				
67 M					
72 M					
80 M					
68 M					
77 M					
77 M					
73 M					
65 F					
74 F					
76 M					
71 M					
76 M					
69 F					
75 M					
75 M					
72 F					
90 M					
82 M					
72 M					
80 M					
73 F					
70 M					
78 M					
80 F					
65 M					
79 F					
69 F					
65 F					
81 M					
77 M					
84 M					
76 M					
80 M					
73 F					
90 F					
73 M					
64 M					
83 F					
79 M					
80 M					
83 M					
75 M					
71 F					
79 M					
86 F					
77 F					
73 F					
70 F					
79 M					
80 M					
77 M					
70 M					
67 M					
82 M					
80 M					
77 F					
79 F					
64 M					
82 M					
90 M					
75 M					
70 M					
79 M					
77 M					
71 F					
75 F					

"Lost" Trap Inventory — Third Phase

Trap Number	Location Site	Sex	Age	19 MAY	16 MAY	27 MAY	22 MAY	23 MAY	30 MAY	31 MAY	4 JUNE	13 JUNE	18 JUNE	19 JUNE	28 JUNE	9 JULY	2 AUGUST	REMARKS
Observation Days →																		
75	F																	I-LD, I-RM, L3, R3M
72	M																	I-LM, RD
71	F																	I-LM, I-RM
81	M																	I-RM
75	M																	I-LM, RM
72	F																	D
80	M																	Note - 19 June - One dead
77	M																	I-LM, RM
71	M																	Black Sea Boss in trap
89	M																	Body D
68	M																	Currier in trap
88	M																	I-LM, RM
76	F																	RM
84	F																	I-LM, RM, all legs M
Observation Days →																		
80	M																	I-LM, RM
82	M																	
76	F																	Recaptured with new eggs - 4 September
75	M																	
Observation Days →																		
78	M																	
78	M																	
81	F																	
75	M																	I - RM
69	M																	
73	F																	
73	M																	I - RM
76	M																	I - RM
71	F																	
79	M																	
87	M																	
78	F																	I - LM
79	M																	
79	F																	RR
72	F																	
73	M																	
75	F																	
84	F																	
82	F																	
76	M																	
76	M																	
74	M																	
Observation Days →																		
86	F																	
73	M																	
69	F																	
76	F																	
80	M																	
77	M																	
77	M																	
83	F																	
74	F																	
79	M																	
77	M																	
72	M																	
68	F																	
77	M																	
75	M																	

"Lost" Trap Inventory — Third Phase

Trap Number	Location	Sex	Age	9 May	16 May	21 May	26 May	31 May	4 June	13 June	19 June	26 June	3 July	2 August	Remarks
Observation Days															
75	M														
62	F														
75	F														
70	F														
68	M														
65	F														
87	F														
76	F														
77	M														
70	M														
71	F														
81	M														
74	M														
76	F														
78	M														
77	M														
72	F														
81	M														
78	F														
82	M														
85	F														
Observation Days															
73	M														
89	M														
89	M														
71	F														
79	M														
75	F														
70	F														
73	F														
78	M														
77	M														
82	M														
73	F														
79	M														
78	M														
70	M														
78	M														
75	M														
77	F														

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A Preliminary Study of Timed Release Mechanisms for Lobster Traps

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ABSTRACT—Possible solutions to the lost ("ghost") pot problem in the offshore lobster fishery of New England are examined in this study. The object was to devise a release so lobsters could escape from ghost pots after a predetermined length of time. The method of release, the release timer, and the release mechanisms were all investigated and tests were conducted on degradable materials to be used for the timing device. The results showed that jute twine and steel wire deserve further consideration, and in situ tests on commercial pots are recommended.

INTRODUCTION

This study was conducted by the Fisheries Engineering Investigation of the Northeast Fisheries Center from January 1973 to August 1974. It was an investigation of possible solutions to the "ghost" pot problem. For this study, ghost pots were defined as lobster pots lost by fishermen which cannot be hauled to the surface because of severed buoy lines. The problem with ghost pots is that they might capture lobsters which die and act as bait for other lobsters, i.e., they are self-baiting death traps. The objective was to devise a "timed release" which would allow the lobster to leave the pot after it had been on the bottom a predetermined length of time.

Three specific problems had to be solved to devise a timed release. They were: 1) What is the method of release? 2) How is the release timed? and 3) How is the release mechanism constructed?

Method of Release

Four release methods were considered: 1) Degradation of natural twine webbing, 2) corrosion of pot-lid hooks,

3) destruction of a wood lath by marine borers, and 4) opening a hinged door with a timed release mechanism. Method number four was selected as the best. The reasons for the selection are covered in the discussion section of this paper.

Release Timer

After selection of the hinged door as the release method, a timing device had to be found which would open the door after a predetermined time. A time interval of 60-90 days was arbitrarily selected because at the outset there was very little information on lobster mortality in ghost pots. The timing device had to meet other criteria as well. The device had to: 1) Be easily checked and reset when the pot was hauled, 2) be strong enough to keep the door closed during hauling, 3) provide consistent opening time, 4) be dependable enough to minimize the loss of catch, 5) be low in cost, and 6) be readily available.

The candidate timing device decided upon was a degradable material which would be tied or twisted around part of the door and part of the lobster pot. This degradable material would act as a latch allowing the door to open when the material failed. Most of the time spent on this project was involved with determining the failure times of materials for this "latch." The materials were chosen for ready availability, low cost, and ease of attachment. The failure

mechanisms were biodegradation, corrosion, and dissolution. The latch-material tests were conducted in Boothbay Harbor, Maine, from January 1973 to September 1973, and in Woods Hole, Mass., from March 1973 to August 1974.

Release Mechanism

In addition to testing the latch material, testing of the release mechanism, i.e., the catch-escape door, also took place. Plastic-coated wire-mesh doors were used in conjunction with the latch-material tests in Boothbay Harbor, and later doors of several material were tested during the Woods Hole pot test. The later doors were designed to include an opening called a sublegal escape vent which allows small lobsters to escape. Sublegal escape vents were being studied by other investigators concurrently with this study.

PROCEDURE

Release Timer

The tests of candidate materials for the degradable latch were intended to indicate ranges of failure times and to show which materials deserved further consideration. The test procedures used were: 1) Boothbay Harbor in situ test rack (TR1) and Woods Hole in situ test rack (TR2), 2) Boothbay Harbor pot test (1973), 3) Woods Hole laboratory test rack (TR3), and 4) Woods Hole pot test (1974).

In Situ Test Racks (TR1 and TR2)

The first procedure entailed setting up nine samples of each of the seven candidate materials in a test rack placed on the bottom in 40 feet of water off Damariscove Island, Boothbay Harbor, Maine, on 27 February 1973. This test rack (TR1) was ballasted and anchored on the bottom. The condition of the materials was checked by the Northeast Fisheries Center diving team during the Boothbay Harbor field tests. An identical test rack (TR2) was placed in 10 feet of water in Great Harbor, Woods Hole, Mass., on 1 March 1973. Test rack TR2 was surface-hauled to check the sample condition. Temperature and dissolved oxygen measurements were periodically made at each location.

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Four samples of each material were near the sea bottom and four were about 35 cm (13.7 inches) off the bottom. The last sample of each material was used to hold a wire-mesh door closed. All samples were held in tension by rubber bands.

The materials tested were: 1) 21-thread cotton with 18.8 kg (41.5 pounds) breaking strength; 2) pure virgin knitted worsted wool—used double; 3) chrome tanned cowhide leather, approximately 0.95 cm × 0.11 cm (0.375 inches × 0.045 inches); 4) polished India jute, No. 36; 5) black annealed steel wire, 18 gauge, 0.12 cm (0.047 inch); 6) 18-gauge steel wire with copper wire twisted around it to produce a galvanic corrosion cell; and 7) strands of manila.

Pure manila twine could not be found at the outset of the project, so ¼-inch diameter, three-strand manila rope (six-thread) was untwisted, and one of the three strands was in turn untwisted into its two component strands. What was left was one-sixth of the original ¼-inch rope, and that was used in the tests.

Pot Test—Boothbay Harbor (1973)

The second procedure was to use the candidate materials to secure catch-escape doors on openings (vents) in 20 pots in Phases I and II of the pot tests at Boothbay Harbor, between January and September 1973. This test was designed to determine the difference in performance between those samples on test racks and those on pots, under the same environmental conditions. Three openings, or vents, were cut in the wire mesh of each pot, one on each side of the parlor and one on the parlor end. The doors were made of wire mesh and were held in tension by rubber bands. Cotton, manila, and steel wire were each used for eight latches, and there were six latches of steel wire in contact with copper wire. The materials were tied or twisted around a bar of the door and a bar of the pot. Ten of the pots were surface-hauled and 10 were left on the bottom for the duration of the test (ghost fished). These pots were concurrently used to study ghost-pot mortality. The results of that study are reported by Pecci et al. (1978).

Laboratory Test Rack—Woods Hole (TR3)

Another test rack, TR3, was constructed for additional material experiments in the laboratory at Woods Hole. Samples were tied vertically in the rack and were attached with rubber bands to keep them in tension. Initially, TR3 was used to test absorbable surgical sutures. Four samples of each of 20 grades of sutures were tested. The sutures are round strands manufactured from mammalian collagen. When used surgically, the body's enzymes dissolve the collagen. Although this process could not be expected to occur in seawater, it was believed that the sutures would dissolve in time. Three types of sutures were tested—medium and extra-chromic types which are tanned to decrease the rate of dissolution and prolong the life of the suture, and plain which is untreated. Suture diameter tolerances are given in Table 1.

Table 1.—Suture diameter tolerances from U.S. Pharmacopeial Convention, Inc. (1955).

Gauge	Diameter (mm)		Diameter (in)	
	Min.	Max.	Min.	Max.
4/0	0.179	0.241	0.0070	0.0095
3/0	0.241	0.318	0.0095	0.0125
2/0	0.318	0.406	0.0125	0.0160
0	0.406	0.495	0.0160	0.0195
1	0.495	0.584	0.0195	0.0230
2	0.584	0.673	0.0230	0.0265
3	0.673	0.762	0.0265	0.0300

After completion of the suture test, TR3 was used to test three diameters of special high-grade, 99.99 percent pure, zinc wire. The diameters of the wires used were 0.14 cm (0.057 inch), 0.16 cm (0.064 inch), and 0.23 cm (0.091 inch). Eight samples of each size were tested, and half of the samples of each size were in contact with copper wire to set up a galvanic corrosion cell.

Also tested on TR3 were eight 18-gauge annealed steel wire samples, four of which were in contact with copper. The black coating on annealed steel is an oxide layer which may reduce the rate of corrosion, and the copper wire had a varnish coating on it, so the samples of steel and copper on TR3 were sanded clean before testing to ensure that the corrosion process was not inhibited.

The rack, TR3, was placed in a fiberglass tank in the Northeast

Fisheries Center's Woods Hole Laboratory to allow daily observations of sample condition. The tank is in the open circuit seawater system. The exchange frequency for the tank's total volume is twice per hour. The seawater is pumped from the harbor into a standpipe, and from there is gravity fed without filtering to the nearby aquarium and laboratories. Aquarium records show the difference in temperature, salinity, and dissolved oxygen between the water in the seawater system and in the harbor to be negligible.

Release Mechanism and Release Timer

Tests of catch-escape doors and latch materials were conducted during Phase III of the field experiment at Woods Hole in 1974. Doors were installed on each of 20 ghost pots and on 20 surface-hauled pots. Ten of the doors in each category were rendered non-functional by tying them closed with nylon twine. The remaining 10 in each category were functional and were latched with wool. Wool was chosen because its mean time to failure in the Woods Hole rack was 92 days and the range of failure times was only 12 days. A catch-escape door was designed which incorporated a sublegal escape vent (Fig. 1). This ensured that all sublegal vents were the same size. The door size allowed large identification numbers to be painted on it. The doors were located on the sides of the parlor section of the pot (Fig. 2). Four door materials were tested: 26-gauge (0.0455 cm, 0.0179 inch) cold rolled sheet steel; 16-gauge (0.161 cm, 0.0635 inch) galvanized steel sheet; ½-inch (3 mm) polyvinyl chloride (PVC) sheet; and ¼-inch thick (6 mm) exterior plywood.

RESULTS

Release Timer

The results of the release-material tests are given by the mean time to failure (MT) of all the samples of a material which were tested by the same method. For each sample failure there was a time interval, between observations, during which the material failed. The time of failure was taken as the

center of the interval. The range of failure times is also given for each set of samples. When an experiment was terminated before all the samples had failed, the number of failures is given, but mean time to failure is not. Due to the small number of samples, no statistical analysis was performed.

In Situ Test Racks (TR1 and TR2)

Unfortunately the Boothbay Harbor test rack, TR1, was filled with seaweed and smashed by a storm 5 weeks after it was emplaced. No failures were observed to have occurred, and testing was discontinued due to the condition of the rack. No problems were encountered

with test rack TR2, located in Great Harbor at Woods Hole, even after being in the water for 287 days. The mean failure times for TR2 materials are shown in Table 2. The difference in mean failure times between those samples on top and those on the bottom was only significant for two materials. The bottom wool samples had failure times 14 percent longer than the top samples. The bottom steel-copper specimens had failure times 39 percent longer than those at the top. A reduction in available oxygen near the bottom because of lower water velocities could have contributed to this difference. It has been shown that the corrosion rate of steel

doubles as the water velocity goes from 0 to 1.5 knots (Tuthill and Schillmoller 1966). Tidal currents in the area of the test rack varied from 0 to about 2 knots.

Pot Test—Boothbay Harbor (1973)

The results of the material tests from both phases of the Boothbay Harbor pot experiment are shown in Table 3. No mean failure times are given because in no case did all samples of a material fail before the tests were terminated. The ranges given are for those samples that failed. Phases I and II were discontinued at 115 days and 90 days, respectively, for reasons unrelated to the material tests. No material showed a significant variation in failure times between the surface-hauled pots and those that ghost fished.

Laboratory Test Rack—Woods Hole (TR3)

The results of the suture tests from TR3 are given in Table 4. Mean time to

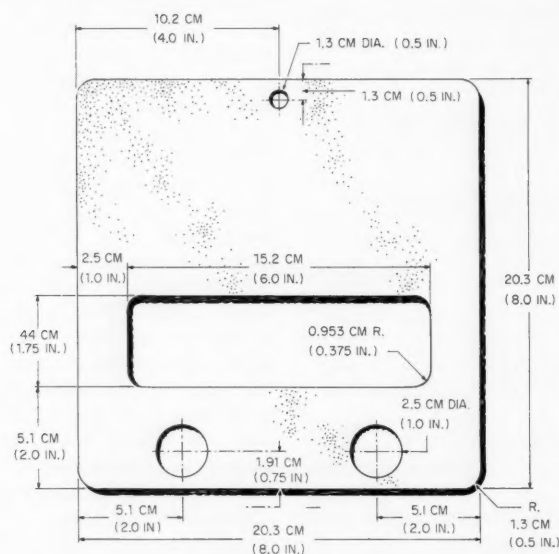


Figure 1.—Catch escape door with sublegal escape vent—Woods Hole pot test.

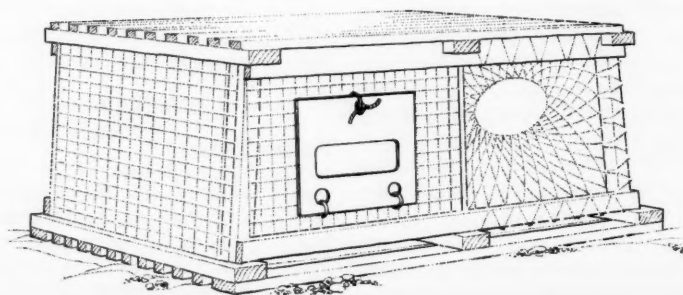


Figure 2.—Catch escape door installed on pot in Woods Hole pot test (1974).

Table 2.—Mean failure times of materials tested in the Woods Hole in situ test rack, TR2¹.

Material	No. of samples	No. of failures	MTTF ² in days	Range in days
Wool	8	8	92	86-98
Wool escape door	1	1	122	
Manila	8	8	150	136-169
Jute	8	8	177	169-184
Jute escape door	1	1	184	
Steel-copper escape door	1	1	184	
Manila escape door	1	1	197	
Steel-copper door	8	8	221	158-272
Steel escape door	1	1	227	
Cotton	8	7		204
Steel	8	3		235
Cotton escape door	1	0		
Leather	8	0		
Leather escape door	1	0		

¹The Woods Hole in situ test rack experiment was terminated after 287 days.

²MTTF is mean time to failure.

Table 3.—Range of failure times for the failed samples of materials tested in Phases I and II of the Boothbay Harbor pot tests.

Material	Phase I			Phase 2	
	No. of samples	No. of failures	Range in days	No. of failures	Range in days
Wool	8	7	64-71	6	51-71
Steel-copper	6	3	58-99	5	65-72
Steel	10	5	71-112	6	71-81
Cotton	10	2	71-112	5	65-88
Manila	10	0		2	81-82
Jute	8	0		1	72
Leather	8	0		0	

failure is not calculated for 3/0 extra-chromic and 1 plain because only three failures were recorded for each. Table 4 also indicates the dependence of suture-failure time on suture diameter. Failure time did not exhibit a dependence on treatment. None of the sutures that were tested met the preliminary objective of 60-90 days duration. However, the suture failure time is dependent on size and larger sizes are available.

The subsequent test of zinc in TR3 was ended after 218 days. At the termination of the experiment not all the samples had failed. The results are shown in Table 5.

The failure of the 0.16-cm diameter samples before the 0.14-cm samples may be insignificant due to the small difference in diameter and the small

number of specimens. However, it could have been caused by changes in the composition between the sizes. The manufacturer states that each size is special high-grade, 99.99 percent pure zinc, but small amounts of impurities can have a marked effect on the corrosion rate of zinc, and this may make zinc a poor candidate for a timing device. The corrosion rate in seawater of a sheet of 99.1 percent pure zinc is reported by LaQue (1948) as 0.0011 inch per year (ipy), while the rate for a bar of commercial zinc with 1.12 percent lead is 0.0036 ipy. Brown (1969) states that the corrosion rate of uncoupled zinc is from 0.0005 to 0.001 ipy. Assuming uniform corrosion at a rate of 0.001 ipy, complete destruction of the smallest zinc wire which was tested should occur in approximately 28 years. This illustrates the great difficulty in estimating failure times from empirical corrosion rates which were determined under different conditions.

Most failures of zinc and zinc-copper occurred at the end of the sample where it was bent around the frame of the test rack. This may have been caused by crevice corrosion occurring in small cracks at the bend or stress-corrosion cracking induced by bending. Brown (1969) reports the crevice-corrosion rate of zinc to be 10 times the normal rate. Failure at the bend contributed to the great discrepancy between predicted and actual failure times.

It is also necessary to take into consideration the strength of the partially corroded material. Some residual strength is necessary for the sample to resist the load placed on it by the door or the rubber band, and it will fail when corrosion has proceeded to the point that the minimum necessary strength has been reached. Table 5 also shows that in each case the zinc-copper samples failed before the zinc samples of the same size.

As the zinc was being tested, steel and steel-copper combination specimens were also tested on TR3; however, the zinc and steel tests were at opposite ends of the test rack to prevent interaction. These steel and copper wires were sanded to remove oxide and varnish coatings. Three of the four

samples each of the steel and steel-copper failed before the test was terminated at day 339. The failure times for the steel-copper samples were between 244 and 339 days. The test was not continued beyond 339 days because longer failure times were not reasonable.

A careful look at Tables 2 and 3 shows the failure times of the materials in the Woods Hole test rack were longer than those in the Boothbay Harbor pot test for each material. In the case of steel, the Woods Hole samples began to fail at 235 days, while in both phases of the Boothbay pot test steel began to fail at day 71, and half or more of the samples had failed in 112 days. LaQue (1948) reported the pitting-corrosion rate of steel over short periods of less than a year can be from 0.04 to 0.1 ipy. Using a rate of 0.1 ipy, the predicted failure due to pitting of the steel wire would occur in 173 days.

This shows that the results from the test-rack experiments cannot be used to reliably predict failure times at other locations, because of variations in temperature, dissolved oxygen, and current velocities. However, the results should be a guide for further testing. The significant differences in the tests were the higher dissolved oxygen content of the Boothbay Harbor waters and that the materials were tested on catch-escape doors in Boothbay Harbor but not in Woods Hole. The doors became clogged with weed, and a storm with winds to 55 mph occurred the week before 3 April 1973, creating strong subsurface surges which persisted for 2 or 3 days. When the pots were checked on 3 April, day 71, 7 of the remaining 56 doors had opened. This accounted for some of the materials failing earlier in the Boothbay Harbor pot tests than in the Woods Hole test rack. The organic fibers all exhibited earlier failures in the second phase of the pot tests than in the first. This was attributed to more rapid degradation of the fibers due to increased biological activity. This increase in activity was caused by the dissolved oxygen content of the water remaining relatively high while the water temperature warmed up over the summer.

Table 4.—Variation of mean failure times of sutures tested in the Woods Hole Laboratory test rack, TR3, in relation to suture diameter¹.

Type of treatment	Gauge ²	MTTF ³ in days	Range in days
Extra-chromic	4/0	3	2-4
	3/0	(⁴)	9
	2/0	20	16-27
	0	33	27-35
	1	51	46-53
Medium-chromic	3	50	30-64
	4/0	6	4-9
	3/0	13	9-16
	2/0	16	14-17
	0	25	24-26
Plain	1	32	25-40
	2	33	18-43
	3	33	27-40
	4/0	12	9-16
	3/0	10	9-13
	2/0	19	16-23
	0	21	18-23
	1	(⁴)	23
	2	30	23-40
	3	38	23-50

¹Four samples of each were tested.

²Diameters are given in Table 1.

³MTTF is mean time to failure.

⁴Only three failures were recorded for this size, and MTTF was not calculated.

Table 5.—Mean failure times of zinc and zinc-copper samples tested in the Woods Hole Laboratory test rack, TR3¹.

Diameter (cm)	Material	MTTF ² in days	Range in days
0.16	zinc-copper	117	56-150
	zinc	132	89-198
0.14	zinc-copper	(³)	123
	zinc	(⁴)	150
0.23	zinc-copper	(³)	150
	zinc	(³)	177

¹Four samples of each were tested.

²MTTF is mean time to failure.

³Only two failures occurred.

⁴Only three failures occurred.

Release Mechanism and Release Timer—Pot Test, Woods Hole (1974)

Eight of the 10 latches on the normally fished pots failed, whereas none of the 10 latches on the ghost pots failed in the 81 days they were on the bottom. This indicated that the wool samples did not have the necessary strength to withstand the load imposed on them by the hydrodynamic drag on the door during hauling. All five of the wool latches on the 26-gauge steel doors failed. The range of failure times was 20-77 days. The 26-gauge material was very thin, 0.0455 cm, and chafing of the latch material probably hastened its failure. Three of the five wool latches on the 1/8-inch thick PVC doors failed at days 41, 57, and 60.

The 26-gauge steel was unacceptable as a door material because it was too thin and bent easily during handling. Plywood was also unacceptable due to delamination of the plies, and because the edges of the sublegal escape vent were gouged and worn by the captured animals. Templeman (1958) referred to the problem of wearing or "chewing" of wood laths which were spaced far enough apart to provide sublegal escape vents. The wood was "chewed" until legal-size lobsters could escape. Because of this a more durable material is needed. The PVC performed well, but became heavily fouled with barnacles. The cost of 1/8-inch thick PVC sheet was \$1.25 per square foot in December 1974. The 16-gauge galvanized steel also performed satisfactorily. Its zinc coating prevented fouling, and in March 1974 it cost \$0.63 per square foot. Of the materials tested, galvanized sheet steel was best. However, the galvanized steel would influence the corrosion rate and failure time of a corrodible latch.

DISCUSSION

Method of Release

Natural Twine

As stated in the introduction, four release methods were considered for this study. The first was to replace a section of the side panel or the head with natural webbing or to tie ("hang")

synthetic webbing with natural twine which would rot and release the captured lobsters. This approach has been tried in the sablefish (blackcod), *Anoplopoma fimbria* and the king crab, *Paralithodes camtschatica*, pot fisheries. Hipkins and Beardsley¹, in their sablefish pot study, estimated that 21-thread cotton-webbing panels would last 5 months, and recommended that the panel be replaced regularly to prevent loss of catch.

In 1970, the State of Washington enacted a regulation stating that a section of one side of a "bottom-fish pot" must be of cotton webbing or hung with cotton twine. The twine size was not specified. However, R. M. Meyer (pers. commun.²) found, while studying the king crab ghost-pot problem, that degradable panels were not acceptable to fishermen due to the possibility of catch losses and the time lost repairing the panels. The same problems have surfaced in the west coast sablefish fishery. Even with materials lasting 6 months, some Washington fishermen regard panel repair as an irritating chore (S. Jaeger, pers. commun.³). Extension personnel from Humboldt State College express the same reservations about the use of panels in the Dungeness crab fishery (S. Ludwig, pers. commun.⁴). It is likely that east coast fishermen would voice similar objections to degradable twine hangings, especially if the time to failure is 3 months instead of the 5-6 months recommended on the west coast.

Pot-Lid Hooks

Another method suggested by west coast fishermen was to use a corrodible metal hook on a rubber band to hold the

pot lid closed. On a lost pot the hook would deteriorate, release the lid, and allow the captured animals to push the lid up and escape (W. Dahlstrom, pers. commun.⁵). However, due to the weight of many of the offshore pot lids, this would not ensure the escape of the animals, although the hook would be considerably easier to replace than a natural twine panel.

Wood Laths

The third technique considered was to have a wood lath nailed over an opening large enough for lobsters to pass through. If the lath was destroyed by marine borers, the lobsters would escape. Failure times would depend on the availability of borers in the fishing area. One report states that offshore oak pots can be destroyed in 3 months by borers (Doliber, 1973), while another says it is not unusual to have one-third of the pots in a string ruined after 4-5 months (New England Marine Resources Information Program, 1972). If all pots broke up this quickly there would be no need for catch-escape mechanisms; however, many pots are treated to reduce borer damage. Brushing a 2 percent solution of TBTO, bis(tri-n-butyltin) oxide, in mineral spirits or kerosene, on dry wood is reported to give 2-year protection in Canadian inshore waters (Thomas, 1968). Florida has enacted legislation which requires pots to be constructed of wood laths to ensure rapid deterioration if lost (Seaman and Aska, 1974), but New England fishermen have turned to composite pots with oak frames and plastic-coated wire-mesh sides to increase the life of the pot and reduce the weight and cost of construction. Replacement of wood-lath escape mechanisms on these pots would be a time-consuming interruption to the normal hauling and setting of the offshore pot strings.

Hinged Door

The last approach considered was to cover an opening in the side of the pot

¹Hipkins, F. W., and A. J. Beardsley. 1970. Development of a pot system for harvesting blackcod (*Anoplopoma fimbria*). A progress report. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Seattle, 31 p. On file at the Northwest and Alaska Fisheries Center, NMFS, NOAA 2725 Montlake Boulevard East, Seattle, WA 98112.

²Alaska Outer Continental Shelf Office, Bureau of Land Management, U.S. Department of Interior, P.O. Box 1159, Anchorage, AK 99510.

³North Pacific Fishing Vessel Owner's Association, Fishermen's Terminal, Seattle, Wash.

⁴Director, Marine Advisory—Extension Service, Humboldt State College, Arcata, CA 95521.

⁵Marine Resources Laboratory, California Department of Fish and Game, 411 Burgess Drive, Menlo Park, CA 94025.

with a hinged-catch escape door kept closed by a latch made of degradable material. This was the release mechanism which was tested (Fig. 1).

Release Mechanism

Doors would be easy for fishermen and enforcement agents to check, and replacement of the latch material would be convenient, whether it be knotting a piece of twine or twisting a wire. Another advantage was that a sublegal escape vent could be easily incorporated in a door by cutting the appropriate size opening in it. Templeman (1958) has reported the enlargement of sublegal vents by "chewing" of the wood laths. If the door material were not wood, this would be eliminated. Jaeger (footnote 3) and Ludwig (footnote 4) think that escape doors would be a better solution to the ghost-pot problems than degradable webbing.

The location of an escape door in a pot is important. Jaeger has reported the loss of catch when degradable webbing in the end of a pot failed during hauling. This could also occur with a door in the lower end. Escape doors should be installed on the side of the pot or the end where the ganglion attaches, to decrease the load on the latch material during hauling. Door location also determines its opening direction. In trapezoidal and half-round pots, a side door has to open inward so it will fall open when the material fails. On a trap with vertical sides, the door should open out, allowing it to be pushed open by the entrapped animals. This eliminates the need for any additional mechanism to open the door after latch failure.

CONCLUSIONS

The results of these tests have provided the basis for eliminating some of the candidate materials, and indicated those which deserve further consideration and testing. Neither wool nor leather met the requirements. Wool was too weak and failed too soon, while leather did not fail. Jute and manila exhibited failure times which seem reasonable to solve the problem and not penalize the fisherman. The range of

failure times of jute was smaller than manila, but it may be difficult to obtain uniform-size jute. If longer failure times are desirable, readily available cotton twine can be used.

The sutures exhibited predictable behavior with an increase in failure time with increasing suture size. However, none of the failure times was long enough to suit our current requirements. Sutures are manufactured in larger sizes which might meet the requirements, but they were not available during testing.

Of the corrodible materials, steel is the best choice. Assuming that the pitting-corrosion rate of 0.1 ipy applies, steel wire of 24-gauge should be tested for a 90-day release time. Steel has the advantages of being readily available and not as subject to changes in composition as organic fibers. The cost of steel wire is approximately the same as that of jute, less than one cent per yard. A bimetallic latch is not recommended because of the cost of having a material specially manufactured. The steel-copper combination did result in a 20-day reduction in failure time compared with the all-steel sample, but a similar reduction can probably be accomplished with smaller-size wire.

Zinc exhibited an unpredictable relationship between diameter and failure time, indicating that more study is needed before a decision on its usefulness can be reached. An uncoated steel door could be used with a zinc latch to produce a galvanic couple, but fouling of the steel would radically change the expected corrosion rate and extend the life of the zinc. As of January 1975, zinc wire cost about three times as much as steel.

The 16-gauge galvanized sheet catch-escape door meets the criteria of cost and durability and is recommended for use if a biodegradable latch is used. If a corrodible latch is used, a nonmetallic door probably will be needed.

Additional studies on jute and steel wire are recommended. These should consist of in situ tests of the materials used as actual latches for catch-escape doors on fished pots. The tests should be conducted in various locations offshore. Inshore tests might be misleading due to differences in dissolved oxygen content, the availability of bacteria which degrade organic fibers, or low temperatures (Klust, 1973). Also, additional strength may be necessary to withstand the load imposed by hauling at high speeds from offshore depths. These are some of the questions which need to be answered in future research.

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The Effects of Different Escape Vents on the Selectivity of Lobster Traps

VERNON E. NULK

ABSTRACT—A laboratory experiment was conducted to determine the American lobster's, *Homarus americanus*, pot related behavior with respect to escape vent size, shape, and position. Carapace width has been correlated with length and found significant in predicting escapement from vents. The American lobster demonstrated an ability to significantly reduce its carapace width to escape through a vent. Data from the laboratory experiments were compared with data from a concurrent field experiment and means were developed to predict catch size distribution as related to vent size when the size distribution of the total population is known.

INTRODUCTION

The lobster pot, or trap, used commercially to harvest the American lobster, *Homarus americanus*, on the New England coast is an example of gear which has been made size selective. Escape gaps, or vents, are commonly created on the sides of the pot by altering the spacing between lower laths, and are intended to liberate sublegal lobsters while retaining the legal catch. The advantages of sublegal escape vents in the northern lobster fishery have been summed up by Templeman (1958).

Much work has been conducted to study the effectiveness of escape vents. In 1943, Wilder (1943) performed size selectivity experiments on lobster pots varying the sizes of fishing rings, or head rings, and lath spacing. According to him, the use of wide lath spacing generally caught fewer "short"

lobsters and more "canners" and "markets." Templeman (1958), in Newfoundland, performed similar experiments on lath spacing with similar results. Bowen (1963) also found size selectivity to be largely dependent on lath spacing in his spearwood crayfish, *Panulirus cygnus*, pots in Western Australia. He was able to calculate the critical retention rates for various escape gap (vent) sizes based on crayfish carapace depth (Fig. 1).

Ritchie (1966) in New Zealand conducted studies with crayfish caught in supplejack, or cane, pots. He experimented with lath spacing, an escape vent panel secured to the pot, and mesh size in an all-steel pot. He considered the total area of the escape vent critical in determining its effectiveness. Winstanley (1971) believed carapace depth in southern rock lobster, *Jasus novae hollandiae*, significant enough in size selectivity to conduct a statistical evaluation of the relationship between carapace length and depth.

Studies such as these have aided fishery managers in determining what

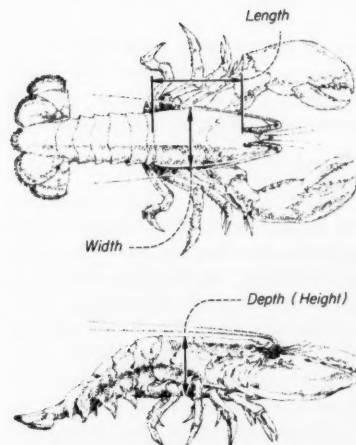


Figure 1.—Definitions of carapace dimensions of *Homarus americanus* and *Panulirus cygnus*.

regulations should be imposed upon the industry. However, each was generally conducted with a specific legal-sized lobster in mind. If legislation were enacted changing legal size limits, it would be difficult to determine what the new optimum vent size or lath spacing should be without reconducting lengthy research programs. It would prove useful, therefore, to investigate methods to more easily identify optimum vent sizes.

The intent of this paper is twofold: 1) Investigate the behavior of *Homarus americanus* relative to escape vents and define the parameters affecting escapement, and 2) develop a method whereby optimum vent sizes may be specified for each lobster fishery as varying legal size limits require.

Laboratory tests to establish a data base were conducted and the results combined with those from simultaneous field tests to compare laboratory observations with actual catch data.

PROCEDURES

Tank tests were conducted in the laboratory in three phases, each studying lobsters' reactions to escape vents varying in size, shape, and position. The tests within each phase are as follows:

Phase I

44-mm vent (1.73 in)

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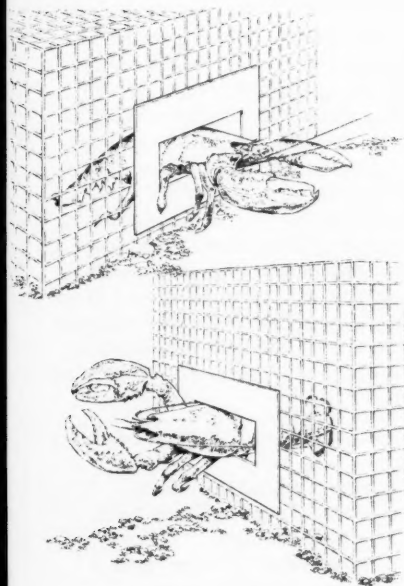


Figure 2.—Escapement as observed in laboratory. Top: "upright" passage through escape vent. Bottom: "on-side" passage.

Phase II

- 45-mm vent (1.77 in)
- 50-mm vent (1.97 in)

Phase III

- 47-mm vent (1.85 in)
- 47-mm vent with increased length
- 47-mm vent positioned high on the pot
- 60-mm circle vent (2.36 in)
- 70-mm circle vent (2.76 in)
- 80-mm circle vent (3.15 in)

Phase I

These tests were conducted from January through June 1973 in a 2,275 l (600 gallon) wood and glass display tank measuring 245 cm (8 feet) long \times 125 cm (4 feet) wide \times 95 cm (3 feet) deep in the National Marine Fisheries Service Aquarium at Woods Hole. A separate 875-l (230-gallon) wood tank measuring 245 cm (8 feet) long \times 125 cm (4 feet) wide \times 45 cm (1.5 feet) deep was used as a holding tank. The tanks were supplied with filtered raw seawater flowing approximately 19-23 l per minute. During the course of the experiment the temperature varied from 0.5° to 19°C. Lighting in the test area consisted of double

122-cm (4-foot) long "cool white" fluorescent tubes running the length of the aquarium, 213 cm (7 feet) above the tank. A single 100-watt incandescent bulb 152 cm (5 feet) above the test tank provided the only illumination at night.

Thirty-seven inshore lobsters ranging in size from 52 to 92 mm carapace length, 69 mm mean length, were collected off the northwest side of the Weepecket Islands and used in this preliminary test. Their sex, length, handedness, and physical condition were recorded. Each was marked with numbered claw bands and placed in the holding tank. During the experiment the held animals were fed sea herring, *Clupea harengus harengus*, or redfish, *Sebastes marinus*, frames every 2 weeks.

A partition was placed in the test tank, separating one side from the other. The vent, measuring 44 mm high \times 152 mm long, was cut out of $\frac{1}{8}$ -inch Masonite¹, then placed on the partition such that the center of the vent opening was approximately 12 cm from the tank floor.

In each test, one lobster was taken from the holding tank at 0900 hours each weekday, its number noted, claws unbanded, and then placed in the test tank. The lobster was encouraged to pass through the vent from one side of the tank to the other side, by various means of enticement. These means included bait attraction, floodlight avoidance, intimidation by a larger lobster, or confinement by moving the partition closer to the lobster to reduce its search area.

During the course of the tank tests, observations were made to study the lobster's reactions to various vents. Early in the experiment we noted that the test animal, when placed in one side of the partitioned tank, would pace the perimeter, randomly reversing direction, and seldom encounter the escape vent. When a lobster approached a corner of the tank, it attempted to climb straight up the wall, and, at times, climbing up the partition and walking

its length to the opposite wall of the tank.

In passing through a vent, a lobster commonly went through, chelipeds first, positioning one on top of the other. It would then maneuver the carapace and tail through, using the legs to assist. Only in two or three instances was a lobster observed backing through a vent, and then only when retreating from another lobster. We found that a lobster too large to fit through the escape vent in an upright position would turn, after its chelipeds were through, and attempt to pass through on its side (Fig. 2). Such maneuvers indicated that carapace width limited a lobster's ability to pass through a given sized vent.

Previous escape gap studies on crayfish and southern rock lobsters consider the smallest outside dimension on the carapace, its depth, an important factor in determining each animal's ability to pass through an escape vent (Bowen, 1963; Winstanley, 1971). An investigation of the morphometrics of *Homarus americanus* revealed that carapace depth consistently exceeds carapace width. Tests were then made to determine the relationship between carapace width and escapement ability.

Lobsters with 44-mm carapace widths proved themselves capable of passing through the 44-mm vent. Therefore, lobsters with widths less than the vent size should likewise have been able to pass through. We refer to this class of "smaller than vent" lobsters as "SV." In Phase I, the percentage of passes occurring in this SV group proved to be lower than expected. In this test it was only 59 percent. A few lobsters with carapace widths greater than 44 mm also passed through the vent. We term these "larger than vent size" lobsters, or "LV." Thus it appears that some lobsters were able to compress their carapace widths to gain access through a vent.

We evaluated the enticement means used in Phase I in an effort to improve the passage of the SV group of lobsters. Where lobsters passed through the vent, we believed 5 percent responded to bait attraction, 21 percent to light

¹Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

avoidance, 31 percent passed during the night, 21 percent passed over the weekend, and 21 percent passed through when placed in the confines of a modified lobster pot. Consequently, procedures for Phase II were modified to replace the partition with a lobster pot to employ further confinement and increased nocturnal activity as the enticement means. This pot is described in detail in Phase II.

Phase II

This phase was conducted from February through July 1974 in a 2,080-l (550-gallon) fiberglass tank measuring 185 cm (6 feet) long \times 122 cm (4 feet) wide \times 92 cm (3 feet) deep, in the Special Projects Laboratory at the Northeast Fisheries Center's Woods Hole Laboratory. The substrate in the tank consisted of sand and gravel. Two separate 305-l (80-gallon) fiberglass tanks divided into 18 chambers 45 cm (18 inches) long \times 25 cm (10 inches) wide \times 18 cm (7 inches) deep were used as holding tanks. The water supply was identical to that of the preliminary test. The water temperature varied from 1.5° to 22°C. The only lighting was sunlight passing around drawn blinds on the south side of the room.

One hundred and one lobsters, ranging in size from 54 to 91 mm carapace length (72.6 mm mean length) and 31 to 58 mm carapace width (45.7 mm mean width), were collected from the same area as before and vital data was recorded in the same manner. Their diet was kept the same, except lobsters to be tested within 5 days were not fed. Claws were not banded on the lobsters that were identified by placing them in numbered chambers in the holding tanks. The rest of the lobsters were banded, and evenly divided between two 360-l holding tanks.

Based on the evaluation of the enticement means used in Phase I, a modified lobster pot replaced the partitioned tank. This plastic-coated steel mesh pot measured 86 cm (34 inches) long \times 56 cm (22 inches) wide \times 35.5 cm (14 inches) high. The parlor head was sewn closed such that only the parlor section of the pot was utilized for the test. The

parlor section measured 43 cm (17 inches) long \times 56 cm (22 inches) wide \times 35.5 cm (14 inches) high. Two sizes of escape vents were tested measuring 45 mm (1.76 inches) high \times 152 mm (5.97 inches) long and 50 mm (1.96 inches) high \times 152 mm (5.97 inches) long. They were cut in 3.1-cm (1.2-inch) Masonite and mounted, one at a time, on the end of the parlor.

Every weekday at 0900 hours, one lobster was placed in the parlor section of the trap and put into the tank. After a 24-hour period (longer on weekends), results were noted as to whether each lobster had succeeded or failed to pass through the vent. The test then resumed with another lobster until all lobsters were tested.

Phase III

Phase III ran from August through October 1974. The tests were held in a 2,080-l (550-gallon) fiberglass tank measuring 185 cm long \times 122 cm wide \times 92 cm deep, and a 2,006-l (230-gallon) fiberglass tank measuring 183 cm diameter \times 76 cm deep. Both these tanks had a sand and gravel substrate.

The divided tanks used in the second experiment and two 360-l (95-gallon) fiberglass tanks measuring 135 cm long \times 75 cm wide \times 38 cm deep were used as holding tanks. Water supply and lighting were the same as the second experiment. The temperature varied from 13° to 22°C.

Forty lobsters ranging in size from 60 to 92 mm carapace length (75.5 mm mean length) and 36 to 57 mm carapace width (46.2 mm mean width) were collected from the same area as before. Individual lobsters were coded for later identification by colored lobster bands placed on the upper part of the chelipeds. Fourteen of the lobsters were each placed in one chamber of the divided holding tanks with their claws unbanded. The 36 remaining lobsters were evenly divided between the two 360-l holding tanks with their claws deactivated by rubber bands to reduce damage from aggression. The lobsters were fed on the same diet and in the same manner as in Phase II.

The number of test pots was increased to four to increase the rate of data return. These pots were made from wire mesh lobster pots by severing the parlor from the kitchen sections and patching the open sides on each with wire mesh and synthetic line. Each pot was made so that a 28-cm \times 28-cm piece of 2.5-cm mesh plastic-coated wire, on which a particular escape vent was mounted, could be moved from one pot to another. All vents were made from 3.1-mm Masonite. The characteristics of the four pots and vents are as follows:

- Pot 1. 56 cm long \times 56 cm wide \times 36 cm high
 - a. plastic-coated steel mesh
 - b. standard vent—47 mm high \times 152 mm long
 - c. approximately 14 cm from bottom of pot to center of vent
- Pot 2. 46 cm long \times 43 cm wide \times 25 cm high
 - a. plastic-coated steel mesh
 - b. lengthened vent—47 mm high \times 228 mm long
 - c. approximately 12 cm from bottom of pot to center of vent
- Pot 3. 46 cm long \times 43 cm wide \times 25 cm high
 - a. galvanized mesh
 - b. high position vent—47 mm high \times 152 mm long
 - c. approximately 21 cm from bottom of pot to center of vent
- Pot 4. 46 cm long \times 30 cm wide \times 25 cm high
 - a. galvanized mesh
 - b. circle vent—80 mm, 70 mm, and 60 mm diameter
 - c. approximately 14 cm from bottom of pot to center of vent

Four lobsters were arbitrarily chosen. They were identified, sexed, measured for carapace length and width, and their physical condition was noted. Then each animal was placed in one of the four pots. The standard and circle-vented pots were in the 530-l round tank, and the high-positioned and lengthened-vent pots were in the 550-l rectangular tank. Each weekday at

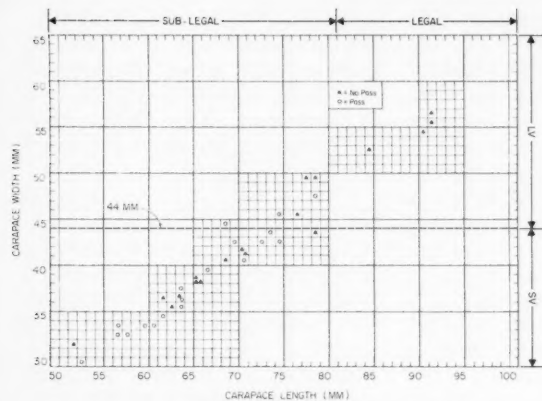


Table 1.—Phase I tank tests, 44-mm vent, 37 samples.

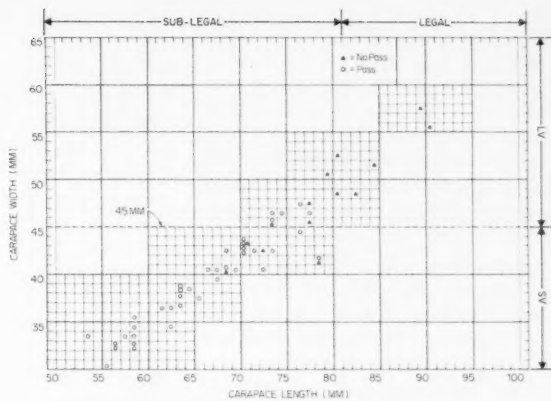


Table 2.—Phase II tank tests, 45-mm vent, 55 samples.

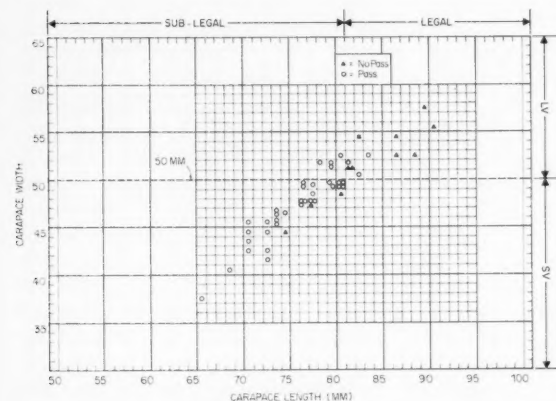


Table 3.—Phase II tank tests, 50-mm vent, 48 samples.

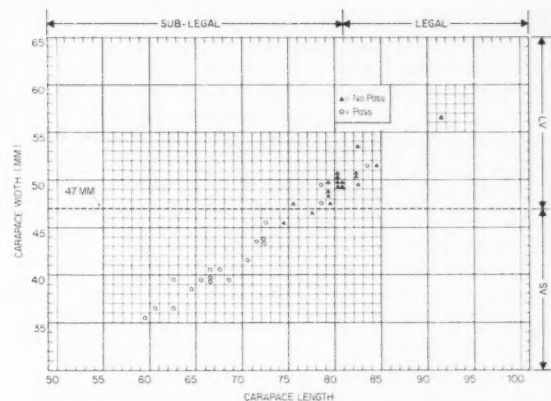


Table 4.—Phase III tank tests, 47-mm standard vent, 38 samples.

1300 hours the location of the lobsters (whether they had escaped through the vent or remained inside the traps) was recorded. Every day the lobsters were moved to different pots. After 4 working days the procedure was repeated with different animals.

RESULTS AND DISCUSSION

Tank Tests

The tank test results are expressed in terms of four basic categories of lobsters. The first two, most commonly used, are legal and sublegal. For the purposes of this study, we define legal lobsters as those with carapace lengths 81 mm and greater, and sublegal as those with carapace lengths 80 mm and less. The second two categories are "LV" lobsters with carapace widths

larger than escape vent size and "SV" lobsters with carapace widths less than or equal to vent size.

Tables 1-9 plot individual lobsters tested by carapace length and width. Lobsters having passed through a given vent are identified by a circle, and those that did not, with a solid triangle. The vent size for each test is given and the division between legal and sublegal sized lobsters is indicated by a heavy dotted line.

Phase I

Thirty-seven lobsters, 27 with carapace widths smaller than or equal to vent size (SV), and 10 with carapace widths larger than vent size (LV), were tested in Phase I (44-mm vent).

In this test, there were 19 passes: 16

SV and 3 LV. The percentage of passes occurring among the SV group was only 59 percent when 100 percent should have been able to pass, based on observations made in this study. The largest LV lobster passing through the vent measured 4 mm greater than vent size. Of the 37 lobsters tested, 33 were classed as sublegal and 4 as legal. All of the 19 passes were sublegal and none were legal, resulting in 57 percent sub-legal escapement and 100 percent legal retention.

Phase II

Phase II of the experiment tested two vent sizes, 45 mm and 50 mm. Fifty-three lobsters were tested in the 45-mm vent tests: 38 SV and 15 LV lobsters.

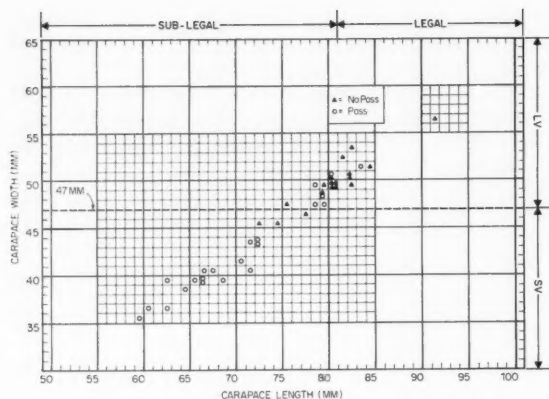


Table 5.—Phase III tank tests, 47-mm lengthened vent, 40 samples.

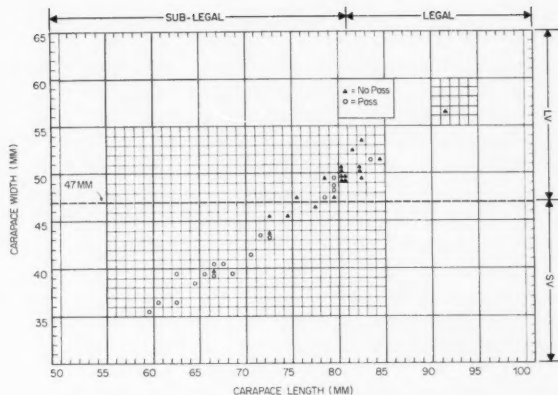


Table 6.—Phase III tank tests, 47-mm high-position vent, 40 samples.

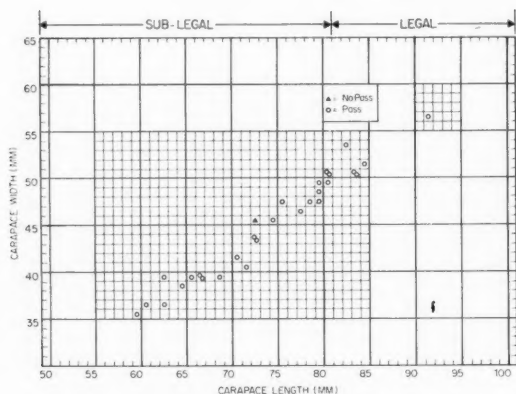


Table 7.—Phase III tank tests, 80-mm circle vent, 29 samples.

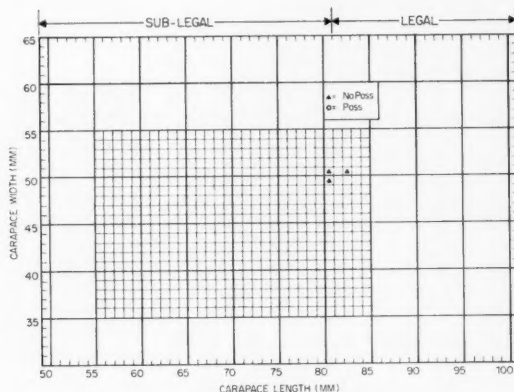


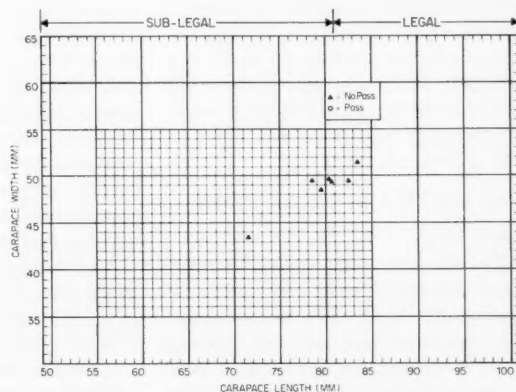
Table 8.—Phase III tank tests, 70-mm circle vent, 3 samples.

Thirty-four SV and 5 LV lobsters passed through the vent, totaling 39. The pass percentage of SV lobsters increased from 59 percent in the Phase I 44-mm vent test, to 89 percent with the 45-mm vent. We attribute this increase at least in part to the use of the modified pot (Phase II) rather than the tank partition (Phase I). The largest LV lobster passing in this test had a carapace width 3 mm greater than vent size.

Forty-seven of the 53 lobsters tested were of sublegal size and 6 were of legal size. Thirty-nine sublegals passed through the vent, equaling 83 percent sublegal escapement. None of the legal lobsters passed, resulting in 100 percent legal retention.

The 50-mm vent was tested with 48

Table 9.—Phase III tank tests, 60-mm circle vent, 7 samples.



lobsters: 33 SV and 15 LV. There were 37 passes in this test: 30 SV and 7 LV, the pass percentage occurring in the SV

group equaling 81 percent. The largest passing LV lobster in this test measured 3 mm greater than vent size.

Of the 48 lobsters tested, 31 were sublegal and 17 were of legal size. The 37 lobsters that passed were comprised of 29 sublegal and 8 legal, resulting in 94 percent sublegal escapement and 53 percent legal retention.

Phase III

This phase consisted of six individual tests, three with 47-mm high vents and three with circular vents measuring 60, 70, and 80 mm in diameter.

The 47 mm \times 152 mm, or 47-mm "standard" vent test used 38 lobsters: 18 SV and 20 LV. In this test there were 19 passes: 16 SV and 3 LV. Thus, the pass percentage of SV lobsters was 88 percent. The largest of the three passing LV lobsters had a carapace width 5 mm greater than vent size.

Of the 38 lobsters tested, 25 were sublegal and 13 were legal sized. Eighteen of the 19 passes were sublegal lobsters. The sublegal escapement equaled 72 percent, while the legal retention was 92 percent.

The 47 mm \times 228 mm, or lengthened-vent used 40 lobsters: 19 SV and 21 LV. The 22 passes occurring in this test consisted of 16 SV and 6 LV lobsters. The percentage of passes among the SV group was 84 percent. The largest lobster passing through the vent in this test measured 5 mm greater than vent size.

Twenty of the 26 sublegal lobsters passed through the 47-mm lengthened vent, while only 2 of the 14 legal lobsters passed through. These passes yielded 77 percent sublegal escapement and 86 percent legal retention.

The last 47-mm vent, the high-positioned vent, was placed higher on the pot than in the previous tests. Thirty-nine lobsters were tested here: 18 SV and 21 LV. Passes through the vent totaled 18, consisting of 13 SV and 5 LV lobsters. The percentage of passes occurring in the SV group equalled 72 percent. The largest LV lobster passing through the vent was 5 mm greater than vent size.

Of the 39 lobsters used in this test, 25 were classed as sublegal and 14 as legal. All but one of the 18 passes were sublegal, yielding 68 percent sublegal

escapement and 93 percent legal retention.

Three vent sizes were tested in the circle vent tests. The first size tested measured 80 mm in diameter. Twenty-nine lobsters ranging in carapace length from 60 to 90 mm were tested, of which all but one passed through. Consequently, the vent size was decreased to 70 mm in diameter. The first three lobsters tested, all legal size, passed and the vent size was again decreased, this time to 60 mm in diameter. Seven lobsters were tested, ranging from 72 to 84 mm in carapace length. None of the lobsters passed through this vent, and the investigation of a relationship between circle vent size and escapement was discontinued due to lack of time.

An ideal vent would, of course, retain 100 percent of the legal lobsters and release 100 percent of the sublegals. The vent tests in the laboratory indicated that, of the sizes tested, the closest approximation to the ideal size for our definition of a legal lobster was the 45-mm vent. This vent retained 100 percent of the legal and released 83 percent of the sublegals.

Ritchie (1966) concluded that one method of improving the effectiveness of a vented crayfish pot is by increasing the length of the gap (vent), and thus, the total escape gap area. The 47-mm "lengthened" vent test investigated the effect of increased vent area with the American lobster. In this test, the vent length was increased from 152 mm (47-mm "standard" vent—7,144 mm²) to 228 mm (10,716 mm²) yielding a 50 percent increase in total area. However, results from the 47-mm "lengthened" vent test showed no improvement over the use of the "standard" 47-mm vent.

During each of the vent tests, at least one lobster whose carapace width was greater than vent size passed through the vent. Although none of the lobsters tested was considered recently moulted, the stage of the moult cycle, i.e., hardness of the shell and amount of meat inside the shell, may have influenced the lobsters' ability to fit through a vent smaller than the lobsters' carapace width.

Field Tests

Strings of vented and nonvented lobster pots were fished in the Woods Hole vicinity as part of a concurrent ghost pot and lobster mortality study. These tests presented an opportunity to test the escape vent in the field. The decision to use 45-mm vents was made on two accounts. The first was the results of the 45-mm tank tests (Table 10) where 100 percent legal retention and 83 percent sublegal escapement was realized. The second was that lobster carapace dimensions taken during these tests showed that legal-sized lobsters (81 mm and greater carapace length) have carapace widths measuring not less than 46 mm. Having no previous indications that the "oversize" passes, observed in the tank tests, occur in the field, we concluded that most legal-sized lobsters should be retained by a 45-mm vent.

The first step taken to analyze data from the field tests, as they relate to the effectiveness of the 45-mm vent, was to assemble a population sample of the American lobster. Our sample totaled 1,523 individuals and consisted of lobsters collected from the Woods Hole area for Phases I, II, and III laboratory vent studies, the nonvented-pot field studies, and from a morphometric study conducted aboard RV *Albatross IV* in 1965. Individuals ranged in size from 54 to 98 mm carapace length, and are plotted in Figure 3 by number of individuals corresponding to a given carapace length and width.

Next, we assumed a lobster will be able to escape only through a vent equal in size or larger than the lobster's carapace width. Figure 4 is a plot of

Table 10.—Legal (81 mm and greater carapace length) retention and sublegal (80 mm and less carapace length) escapement percentages for each vent tested in the tank tests.

Vent size	Legal retention	Sublegal escapement
Ideal	100	100
44 mm	100	58
45 mm	100	83
47 mm standard	92	72
47 mm lengthened	86	77
47 mm high position	93	68
50 mm	53	94
60 mm circle	100	0
70 mm circle	0	No sublegals tested
80 mm circle	0	100

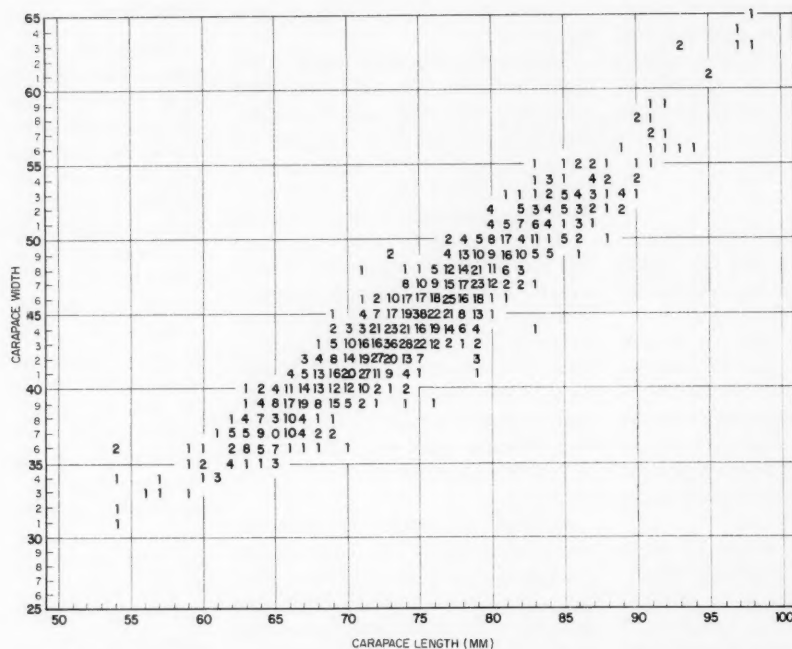


Figure 3.—*Homarus americanus* population samples from New England coast (lobsters collected from Phase III nonvented field tests, Phases I, II, and III tank tests, and from a 1965 cruise aboard *Albatross IV*—1,523 samples).

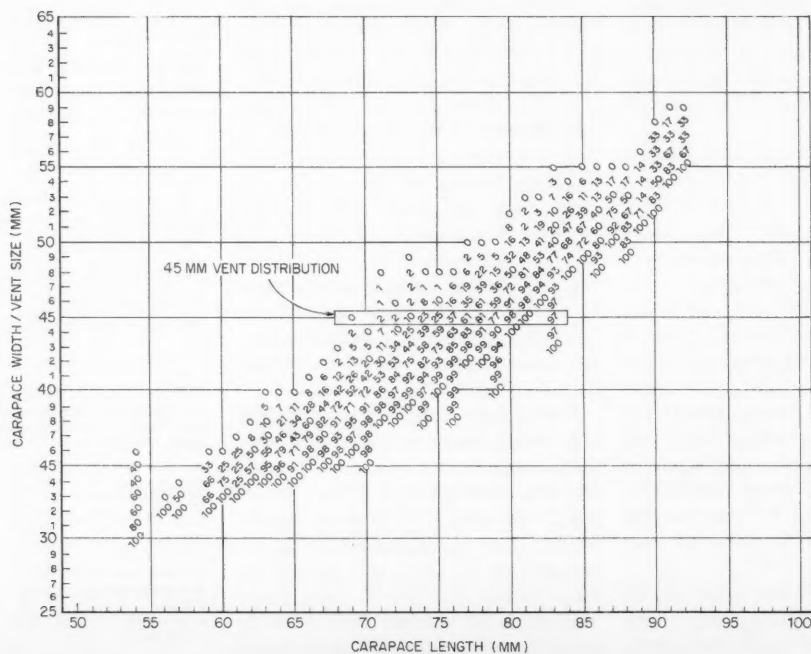


Figure 4.—Theoretical retentions for escape vents.

calculated retention percentages for each vent size by carapace length. These percentages were derived by examining the distributions of carapace widths for each carapace length in Figure 3. By calculating the percentage of individuals retained each time a vent size is considered within the column of a specified carapace length, a range of retention percentages is assigned to each carapace length. For example, consider the carapace width distribution at 65 mm carapace length. The number of lobsters occurring at 40 mm carapace width is four; but if we assume a 40-mm vent is used on a theoretical pot, all lobsters in the 65 mm carapace length column would escape as all carapace widths are equal to or less than vent size:

$$\frac{\text{No. lobsters w/carapace widths greater than 40 mm}}{\text{Total no. lobsters w/65 mm carapace length}} = \frac{0}{25} = 0\%$$

Retention of individuals at 40 mm carapace width and 65 mm carapace length would be 0 percent for a 40-mm vent (see Fig. 4; 65 mm carapace length \times 40 mm vent).

Moving down the 65 mm carapace length column in Figure 3, there are eight individuals corresponding to 39 mm carapace width. If a 39-mm vent is now considered, all the lobsters with carapace widths 39 mm and less would escape, but the four widths of 40 mm would not:

$$\frac{\text{No. lobsters w/carapace widths greater than 39 mm}}{\text{Total no. lobsters w/65 mm carapace length}} = \frac{4}{25} = 16\%$$

Four lobsters retained out of the 25 in the column results in 16 percent retention (entered in Fig. 5).

Such retention percentages were calculated for the columns at each carapace length in Figure 5, and the distribution of percentages at 45-mm vent (outlined) was later applied to a theoretical escape vent.

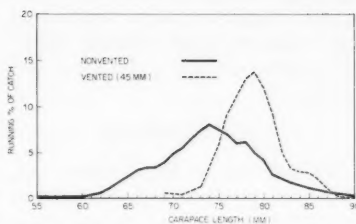


Figure 5.—Catch size distributions from nonvented and 45-mm vented pots fished in Phase III field tests.

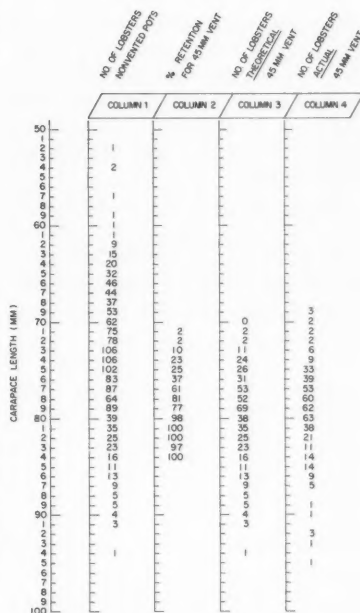


Figure 6.—Summary of theoretical catch calculations and actual catches from Phase III field tests.

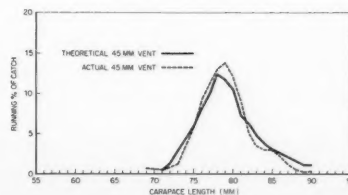


Figure 7.—Theoretical and actual catch size distributions using a 45-mm vent.

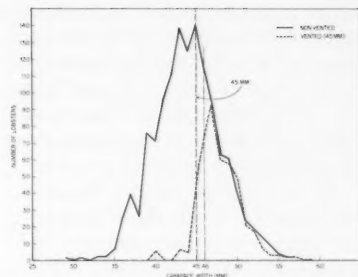


Figure 8.—Comparison by carapace width of catch size distributions from nonvented and 45-mm vented pots.

The field test catches were plotted in Figure 5, and we found a significant reduction in sublegal catch while retaining most of the legal by the use of the 45-mm vent. The nonvented catch totaled 1,304, 1,154 of which were sublegal and 150 legal. The vented catch totaled 454: 335 sublegal and 119 legal. Assuming the nonvented catch was representative of the lobsters entering the vented pots, the use of the 45-mm vent resulted in 71 percent sublegal escape-ment and 79 percent legal retention.

A theoretical vented catch (Fig. 6, column 3) was calculated by multiplying the 45-mm retention percentage for a given carapace length (column 2) by the number of individuals from the nonvented population (column 1) at the same carapace length.

Comparison of the actual and theoretical vented catches shows differences between the two in actual numbers of lobsters caught. The actual vented catch totaled 454: 335 sublegal and 119 legal. The theoretical vented catch totaled 458: 308 sublegal and 150 legal. However, when expressed in terms of running percentages (Fig. 7), the two catches compare favorably, indicating that our estimate of catch composition is fairly accurate.

Figure 8 illustrates escapement and retention characteristics of the 45-mm vent used in the field tests when examined in terms of carapace width. Here we found 92 percent escapement among individuals with carapace widths less than or equal to the 45-mm

vent and 88 percent retention of those larger than vent size. The difference between the two curves at 46-mm carapace width is the first indication that oversize passes occur in the field, and that as much as 33 percent or 38 individuals with widths of 46 mm may have escaped through the 45-mm vent.

We considered altering basic assumptions in the calculation of theoretical catches to include probable oversize passes. However, because the tank tests included passes of up to 5 mm oversize, and the field tests indicated oversize passes only 1 mm larger than vent size, we decided to reserve any modifications in calculations until more information is available on the frequencies of occurrence and the size ranges of oversize passes in the field.

Theoretical catch compositions were calculated for a range of vent sizes. Table 11 shows that the 47-mm vent would yield 97 percent legal retention and 90 percent sublegal escapement where minimum legal size is 81-mm carapace length. Vents larger than 47 mm would release more sublegal lobsters, but because substantial overlap of carapace widths occurs between

legal and sublegal lobsters at 81-mm carapace length, the larger vents would begin reducing legal retention before 100 percent sublegal escapement was realized.

CONCLUSIONS

Our tests indicate that a lobster pot, fitted with a single escape vent measuring 45×152 mm makes the pot effectively size-selective where legal size is 81-mm carapace length. A 47-mm vent may greatly increase sublegal escapement without significantly affecting legal retention, but has yet to be tested in the field.

Ritchie (1966) concluded that by increasing the length of the vent, the effectiveness of the vented pot increases also. Our laboratory tests did not bear this out, but perhaps further tests, focusing on the effect of increased vent length on escapement, would determine if vents longer than 152 mm are advantageous.

The circle vent tests proved little more than to say that, if a circle proves to be an effective vent shape, considerable testing would be required to determine an optimum size.

Similar to studies by Bowen (1963) and Winstanley (1971), we found a relationship between carapace length and width significant in predicting escapement from vented pots. Laboratory tests show that lobsters may turn on their sides to escape through a vent otherwise too small, and that some have fit through a vent as much as 5 mm smaller than their carapace width—the smallest dimension on the carapace. Field tests demonstrated that as many as 33 percent of the lobsters with carapace widths 1 mm larger than vent size, may have escaped through a vented pot.

We have developed a method to calculate theoretical catch size distributions for any size escape vent. If it can be determined that a known population sample is applicable to many fisheries on the New England coast, then substantial savings may be realized in the reduction of costly research programs to determine optimum vent sizes.

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Table 11.—Legal retention and sublegal escapement for theoretical vents.

Vent or nonvented	Total no.	Legal lobsters	Legal retention	Sublegal lobsters	Sublegal escapement
Nonvented	1,304	150	—	1,154	—
44 mm (Theoretical)	593	150	100%	443	62%
45 mm (Theoretical)	458	150	100%	308	73%
46 mm (Theoretical)	339	148	97%	191	83%
47 mm (Theoretical)	257	145	97%	112	90%

MFR Paper 1309. From Marine Fisheries Review, Vol. 40, No. 5-6, May-June 1978. Copies of this paper, in limited numbers, are available from D822, User Services Branch, Environmental Science Information Center, NOAA, Rockville, MD 20852. Copies of Marine Fisheries Review are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402 for \$1.10 each.

Trap Design and Ghost Fishing: Discussion

RONALD JOEL SMOLOWITZ

ABSTRACT—This paper presents an assessment of ghost fishing in the New England lobster fishery by reviewing trends in trap design, loss rates, lost-trap catch rates, and related factors. Preventative solutions are discussed.

The studies presented in this issue of *Marine Fisheries Review* (40:5-6) are ultimately concerned with developing preventive measures to avoid a ghost-fishing problem. In researching preventive measures, information has been obtained which enables us to make a preliminary assessment of the ghost-fishing situation as it exists today and what may occur in the future. This discussion presents this assessment and reviews preventive measures.

NUMBER OF POTS LOST

By 1973, the number of lobster (*Homarus americanus*) pots being fished along the Atlantic seacoast exceeded 2 million. The annual inshore loss rate is claimed by many fishermen to be between 20 and 30 percent; one published estimate is 33 percent (Prudden, 1962:43). Most of these pots are all wood or wood framed and were effective fishing units when lost.

There are many reasons why pots are lost in the inshore fishery. Gear failure includes the pot warp parting, the buoy separating from the pot warp, and the buoy breaking up. This gear failure can be caused by normal wear and tear, powerboat propellers, pot "wars" among lobstermen, sea gulls chewing up buoys, fish biting the warp, and many other causes. Losses are also caused by operational mistakes such as setting too deep and improper ballasting. Storm surge can cause the pot to roll on the bottom, wrapping up its buoy line, and becoming unrecoverable.

In the offshore fishery in 1976, there

were about 72,000 pots being fished by 150 vessels. Roughly two-thirds of these pots were of wood-frame construction, the remaining third were all metal with nylon heads (NMFS, unpubl. data¹). The loss rate offshore has varied considerably from year to year and vessel to vessel. Annual loss rates of 100 percent were common in 1971-72 but decreased to 20-30 percent by 1974. Based on confidential information gathered from logbooks and other sources, there may be as many as 40,000 all-metal pots lost on the offshore grounds since 1971. Approximately 180,000 wood-frame pots were lost offshore during the same period.

Offshore losses are mostly caused by vessel propellers, dragged gear, gear mechanical failure, and storms. Experience gained by fishermen has cut these losses to where, in many cases, they are equal to inshore loss rates.

Loss rates, both inshore and offshore, will probably remain in the 20-30 percent range. However, the number of pots in both fisheries is increasing, thus the absolute number of pots lost will probably increase also.

POT TYPE

Pot type, as specified by design and materials, is one of the key indicators of whether a ghost-fishing situation will be created. The pot-design problem, as defined by history, can be simply stated as: To build the most durable pot, for

¹Interview sheets on file at the Woods Hole Laboratory, Northeast Fisheries Center, National Marine Fisheries Service, NOAA, Woods Hole, MA 02543.

the lowest cost, that catches and retains the greatest amount of legal-sized lobsters in good condition. The design parameters are interrelated with the overall economics of the fishing operation as well as with each other. This section will focus on the various design factors in order to predict which way trap design may go.

Size

The size of the pot is usually dictated by handling problems, deck space, and expected catch rate. In the inshore fishery, where the availability of legal-sized lobsters is low and the boats are small, the pots are small. A lobsterman who hauls his pots every other day instead of daily might use a slightly larger pot if he expects a larger catch.

In the offshore fishery the pots are larger due to the larger vessels, longer soak periods, and higher availability of legal-sized lobsters.

Both inshore and offshore, larger pots are claimed by many fishermen to catch more lobsters. This may occur because lobsters have a more difficult time finding their way out of the pot due to the increased area to be searched. Another reason may be a lobster-density limitation, which we will cover later on in this discussion.

The deck space limiting factor of large pots can be dealt with by using collapsible or stackable pots (Munro, 1973).

Shape

The shape of the pot is important in determining its resistance to storm damage. Improper shape can cause pots to turn over and roll along the ocean bottom when subject to wave action. Prudden (1962:44) makes the following suggestions to reduce pot losses: 1) Any reduction in the height of a pot from the present 18 inches would reduce the leverage tending to overturn a pot; and 2) The construction of a pot with inclined sides like a pyramid would change the side pressure of a wave from an overturning effect into a force pressing the pot down on the ocean floor.

Proper settling of the pot on the bottom is also a function of shape. Drag

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forces acting on the pot as it settles through the water column determine how the pot is going to land. Stability, a function of weight and shape, determines how the pot will remain on the bottom (Burgess, 1969). If the pot does not assume the correct position on the bottom, the entrance heads can become obstructed or ineffective (Fig. 1).

Pot shape also determines what shape the heads will take. The reason that most pots are high and long as they are is to allow for a more effective head design.

Head Design

As the catch rates fell in the inshore fishery, the soak periods increased in order to maintain an economically viable catch. The 15-minute soaks of hoop nets gave way to the full-day soaks of the single-compartment pot. The parlor pot became necessary when soaks exceeded 1 day.

The key problem with longer soak times is how to prevent escapement once the lobster enters the pot. The answer, for the past century, has been better head design. Rathbun (1887) describes variations in head design based on reorienting the position of the head ring, e.g., the opening facing slightly up instead of straight into the pot. He also describes pots with tandem heads made of wood laths, two types that are still seen today.

Thomas (1959) has conducted numerous experiments to improve the efficiency of pots. He has shown that: 1) Lobsters enter a pot more readily if the lower half of the head is lined with fine-mesh netting, 2) high-rigged heads inhibit escape better, and 3) head-opening size affects the number and size of lobsters caught, as does the fitting of nonescapement devices. He further states that the effects of pot variations differ with the size and composition of the population being fished and other fishing conditions.

Leakey (1965) feels parlor pots are a waste of space and materials. His solution to the retention problem is an escape inhibitor that he has patented. This inhibitor, as with many similar devices known generally as triggers, allows the lobster to enter through the head but prevents its escape back out. Triggers have been tried or are in use in many

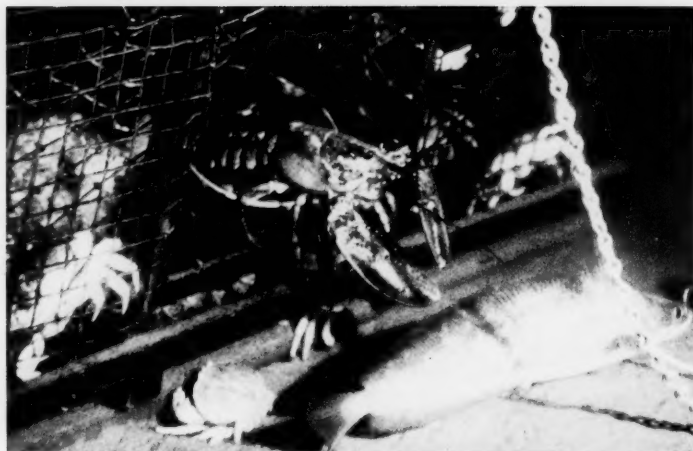


Figure 1.—Lobster escaping from an offshore trap that landed upside down.

areas but there is still quite a bit of controversy as to their effectiveness.

Spurr², after comparison fishing five different types of pots, believes that the principal factor affecting pot efficiency is not pot shape but parlor-head design. He believes that the parlor head should have a long steep slope terminating in a small opening very close to the end of the pot and near the top. This agrees with Thomas' (1959) findings that high-rigged heads deterred escape. Our field data confirms Spurr's and Thomas' observations and further demonstrates the degree of sensitivity parlor head design parameters have that affects ingress and retention.

Moody (1965), from a pot-escapement experiment, obtained results that showed 90 percent of the lobsters caught in unbaited pots escaping within 3 days. In baited pots, the escapement rate was 90 percent in 8 days. While it is difficult to make a direct comparison of Moody's work with our field experiments, it seems he had a higher escapement rate. We hypothesize that this is due to the fact that he used wood-lath parlor heads which may be less efficient in retaining lobsters than our nylon-twine skate-mouthed heads. On the other hand, wood-lath heads may allow more lobsters into the parlor in that they pro-

vide better footing than nylon netting (Prudden, 1962:41).

The way the entrance head is attached to the bottom of the pot may also be important. Wilder³ (p. 5) found that wide spaces along the lower sides of the pot made it difficult for the lobster to find the head and thus enter the pot.

Materials

For the purposes of this discussion we have grouped pots into three categories: wood and wood-framed, metal, and plastic.

Degradation

Wood borers are probably the primary degrading force acting on wood pots. Borer damage can destroy a wood pot as an effective fishing unit in as little time as 4 weeks. On the other hand, a treated wood pot may last upwards of 2 years on the bottom in areas with low borer activity. Wood borers do not affect metal or plastic pots.

Corrosion affects metal fastenings on wood pots, wire mesh on wood and metal pots, and wire mesh and structural frames on metal pots. There are many ways to cut down the corrosion rates, such as plastic coatings, designing against galvanic corrosion, anodizing aluminum, etc. Leakey (1965) reports zinc-coated metal-framed pots

²Spurr, E. 1972. Lobster research project: Final report of 3-105-R. July 1969-June 1971. Unpubl. manuscr., 22 p. Fish. Div., New Hampshire Fish Game Dep.

³Wilder, D. G. 1956. Experiments to improve lobster traps. Unpubl. manuscr. Fish. Res. Board Can., Biol. Stn., St. Andrews, New Brunswick.

lasting over 5 years and some lasting 7 years. Proper anticorrosion design can probably extend a metal pot's life beyond 10 years. Plastic pots do not corrode.

Weight

Metal pots have weight advantages far exceeding wood pots. They are lighter out of water and heavier in water. In tests conducted at the Northeast Fisheries Center (New England Marine Resources Information Program, 1972: 2), one metal and one wood pot were weighed in and out of water. The water-logged wood pot weighed 22 pounds in water and 115 pounds out of water. The wire-mesh metal pot weighed 33 pounds in water and 53 pounds out of water. Metal pots are thus easier to handle on deck and have better anchoring qualities on the bottom.

Plastic pots vary, in regard to weight and buoyancy, with the type of plastic used and the construction method.

Storm Damage

Metal pots are probably more resistant to storm damage than wooden pots of the same size and shape because of their greater weight on the bottom and less surface area exposed to storm forces.

In a series of comparison-fishing experiments, Wilder (footnote 3, p. 23) reports that during a severe storm he lost 14 out of 19 wood pots with the remaining 5 damaged almost beyond repair. Only 1 out of 19 metal pots was lost during the storm. Similar results occurred during several other storms throughout his experiments. Metal-pot losses that did occur were attributed to buoy line failures.

Experiments by Spurr (footnote 2) provide the same results: wire-mesh pots moved less in current and storm action than wood-lath pots.

Costs

The material to build an inshore wood pot costs from \$4 to \$6. To buy a pot already constructed costs from \$8 to \$14. Inshore metal pots cost about \$20.

Offshore double-parlor wood pots cost \$18 in 1972. In 1974 the cost was \$27. Metal pots of the same design were \$24 in 1972, \$35 in 1974, and close to \$40 in 1977.

Efficiency

There is a traditional belief among lobstermen that metal pots are not as efficient as wood pots. Some of the reasons why lobsters are said to be repelled by metal pots are: 1) Metal wire vibrates in the water frightening the lobsters away, 2) lobsters do not like the feel of bare metal, 3) lobsters are sensitive to sharp metal edges, 4) lobsters sense an electric field set up by galvanic action, and 5) lobsters sense chemicals produced by galvanic action.

There are many variables that affect a pot's efficiency, though little is known about how or why. Very little comparison fishing has been performed and documented. Experiments that have been done have not had ample controls to determine if metal construction alone affected pot efficiency. We can say that the five objections to metal pots stated above have been overcome by proper construction and plastic dipping. Many fishermen have reported plastic coated and aluminized metal pots fished well.

Adaptability

Metal and plastic are more adaptable than wood in pot designs that are either collapsible or stackable.

Handling

Wood and wood-framed pots can take a lot more abuse in handling than wire pots. This can be compensated for by building the wire pots stronger and more rigid by addition of a structural metal frame. Shipboard handling systems can also be modified to be less abusive to the pots as they come aboard.

Wire pots have a handling advantage over wood in that they offer less resistance when being hauled up through the water.

Catch Condition

The catch suffers a significant degree of claw damage and loss in wood pots due to claws protruding between the laths and being hit when hauled aboard. This problem is eliminated in wire-mesh metal pots.

Pot-Type Summary

Researchers generally agree that lobster-pot design has not been op-

timized. The preceding discussion on pot design and materials demonstrates the fact that pots can now be designed that are more durable and efficient than the ones being fished commonly today. The probability of a long-term ghost-fishing situation being created will only increase.

LOCATION WHERE LOST

Biological Deterioration

Since most lobstermen use synthetic twine in pot construction, the main form of biological deterioration of concern is wood-destroying organisms. In the lobstering areas the organisms are usually *Teredo navalis* in the shallow depths and *Xylophaga atlantica* in the deeper part of the range.

Teredo navalis spawns about July. The larvae settle onto the wood traps and can destroy a trap in less than 2 months. Offshore *Xylophaga atlantica* spawns about October and can destroy a trap just as fast.

It is generally thought that most lobster areas are subject to wood-borer activity, though not of the same magnitude. In most inshore and offshore areas an untreated wood trap would probably not make it through the winter.

Corrosion

Location-dependent factors that influence corrosion are temperature, dissolved oxygen, and current velocities. Our trap-release study demonstrated the significant difference in failure rates that occurred with test samples in different areas. Corrosion rates are probably higher inshore than offshore.

Storm Surge

Storm surge and wave action are known to destroy many pots in shallow inshore waters. Though pots without buoy lines are less susceptible to storm action, they too probably move on the bottom in depths less than 20 m. It is generally believed by lobstermen that pots moved by storms tend to break up against rocks on the bottom.

Summer fishing is usually in shallow depths. As fall and winter approach, pots are usually moved farther offshore into deeper water to follow the lobsters

and also to reduce storm losses. Pots that were lost during the summer in the shallow water probably do not survive the winter storms on exposed coasts.

Substrate Burial

Pots sometimes become buried in the substrate by the action of storms and currents. This is commonly referred to as "sanding down" or "mudding up." Sanding down is quite common, in depths shallower than 16 m, in the west coast Dungeness crab fishery (Hipkins, 1972:9). In this fishery a pump is carried on board with a special hose arrangement that can be lowered to the pot and water pressure applied to free the pot, sometimes buried to a depth of 4 m.

To what degree this problem exists in the lobster fishery is unknown. We can assume that a pot only needs to be buried about 15 cm in the substrate before its heads become relatively ineffective. There are many areas, inshore and offshore, where the bottom conditions of substrate and current are right for partial burial to occur (Fig. 2).

Destruction by Dragged Gear

Offshore lobstermen set their pots following the migrations of lobsters from the deep canyons in winter up onto the shallow shelf in summer. Many pots are lost in areas that are not continuously pot-fished. When the pot fishermen move out, the draggers move in, fishing the bottomfish in the area. These draggers haul back many lost pots and quite possibly destroy many others on the bottom. Only pots in the canyons themselves probably escape being destroyed by draggers.

CATCH RATES

Ingress minus escapement and trap mortality equals retention or, in other words, the catch. Catch rate is a time function; in trap fishing the time is defined in set-over days.

Set-Over Days

Set-over days are probably very important in determining rates of trap-related injury and mortality, in addition to their importance in catch/effort relationships. Unfortunately our data is not

sufficient to perform a statistical analysis because we cannot isolate the effects of temperature, fishing pressure, and moulting from those of set-over days. (Our surface-hauled traps had set-over periods varying from 1 to 13 days).

We divided set-over days into three basic periods. The first is the baited period, in which some of the initial bait is still in the trap and is effective. The second is the transition period, in which the bait is recently gone and the lobsters caught are highly active in attempts to escape. The third period is the ghost-fishing period. The limits of the transition period cannot be exactly described, but in most cases the trap probably entered the ghost-fishing period by the end of the second week.

There may be times of increased ingress to the trap during the ghost-fishing period. This may be caused by the trap self-baiting, a lobster migration, or some seasonal event. This makes it very difficult to relate ghost-catch rate to set-over days. This is further compounded by the low ghost-fishing period catch rates, in our experiment equal to 10 percent of the surface-hauled catch rate.

Availability and Catchability

Ingress is a function of availability and catchability. A good example of the variation in availability of lobsters to a possible ghost trap can be found in the fishing strategy used offshore. As the

bottom water temperature changes, the lobster population migrates and the fishermen correspondingly move their traps. A trap lost in a location where there were good catches one week may not have lobsters available to it for weeks or months afterwards.

Many factors affect catchability but probably the most important are temperature and other seasonal variations. Since ghost traps are on the bottom for long periods, the lobsters available to them will have a wide range of catchability coefficients varying with time.

In summation, availability and catchability cannot readily be used for an assessment of ghost-fishing period catch rates due to their variability. However, during the initial baited period these factors can be used for estimating the initial catch, which during our experiment was more than 50 percent of the overall ghost catch.

Escapement

In our Phase III experiment, 81 lobsters were classified as missing from the ghost traps, this being 33 percent of the known ingress. Two-thirds of this number were missing by the 30th day. Only six of these lobsters were recaptured. We conclude that the escapement rate from ghost traps, after the initial baited and transition periods, is less than 30 percent. This rate decreases with time. This figure is in basic agreement with that of Sheldon and Dow (1975).

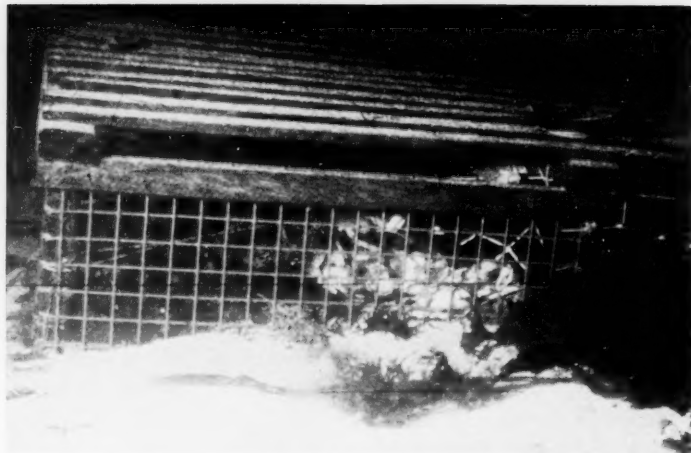


Figure 2.—Lobster trap partially buried in sand after several weeks on the bottom.

Bait

There are a number of artificial lobster baits on the market; they have been used by fishermen with varying degrees of success. One of the goals of the artificial bait manufacturers is to produce a product that is long-lasting in the trap. Accomplishment of this goal would improve the trapping efficiency for longer set-over periods. Correspondingly this would increase ghost-fishing catch rates.

Behavior

The most interesting question about trap-related lobster behavior is why do lobsters enter traps? We must address this question to fully understand trapping efficiency and thus normal and ghost-fishing catch rates.

We know that lobsters primarily enter traps to get food (bait). We also know that lobsters enter unbaited traps, and this is usually thought to be shelter-seeking behavior. In the natural environment inshore lobsters are considered solitary, rarely sharing the same shelter. Offshore, on relatively flat featureless bottom, two or more lobsters have been observed to share the same shelter, usually a depression in the bottom. This observation is the exception though.

This natural solitary behavior is opposite what is observed in trapping. Our field experiment catch data shows many instances, especially in Phase III, where 15 or more lobsters were found in a trap, sometimes after 8 set-over days. Many of those lobsters entered the trap after the bait was gone. The same observation is demonstrated by our "lost" trap inventories. There is ingress to unbaited traps with large numbers of others lobsters present. This is in an area with plenty of available shelters.

We assume that a lobster entering a trap with 10 other individuals already there is aware of their presence before entering. Lobsters possess visual, chemical, and possibly sonic means of communication. The lobster may be entering for some social interaction with its conspecifics.

To determine the effects of social behavior on catchability, Edward

Leger, a Boston University Marine Program graduate student, conducted a preliminary experiment at the Northeast Fisheries Center in 1973. Sixteen inshore lobsters (70 mm \pm 2 mm carapace) and 16 offshore lobsters (74 mm \pm 2 mm) were tested in 2-m diameter circular tanks under three different conditions. Capture time was recorded for each lobster placed in the tank with: 1) Trap and bait alone, 2) trap with bait and one lobster, and 3) trap and bait and two lobsters. During 1-hour test periods, 14 of 16 lobsters tested entered the trap with bait alone; 26 of 32 lobsters entered the trap containing bait and 1 lobster; none of 6 tested entered the trap with bait and 2 lobsters. This experiment indicated a possible density limitation factor in trap behavior.

Evidence exists that some form of social behavior, other than feeding and shelter related, is affecting catchability of lobsters. Leger's experiment seems to conflict with the field data, indicating the need for more closely controlled experiments to validate the social behavior hypothesis.

Another hypothesis is that lobsters enter unbaited traps because they have been conditioned to do so. Every week lobstermen place millions of pounds of bait into the water via lobster traps. This may constitute the major food source of lobsters who thus relate feeding with traps. Upon seeing a trap a lobster enters expecting a food source. Probably small (sublegal) lobsters have been repeatedly caught and discarded by fishermen as they became conditioned to traps being effectively a feeding station. Lobsters repeatedly return to the trap as a food source, much as birds return to window feeders. Lobsters may enter unbaited pots simply to "check-it-out" for food.

Injury and Mortality

Emmel (1905) reported that 7 to 25 percent of lobsters caught in Rhode Island were missing one or both claws. Scarratt (1973) found incidence of claw loss from 5 to 19 percent in Canadian waters. Other wounds ranged from 1 to 11 percent in the lobsters sampled. Krouse (1977) analyzed Maine catch data which indicated 6.5 percent of lobsters caught were missing at least

one claw and 21 percent had missing and/or regenerate claws.

Our field data for all three phases combined (surface hauled) shows 11.2 percent of the lobsters caught missing one or both claws. The overall incidence of lobsters with one or more types of damage is 27.6 percent. This field data may not truly reflect what is occurring in the actual fishery due to our longer set-over periods. Our data does show that the number of injuries might increase with longer set-over periods, increases in water temperature, increases in fishing pressure, and possibly be related to moulting. More controlled experiments are needed to determine the effects of each of the above factors.

Incidence of newly damaged lobsters during a portion of the Phase III study was similar for vented and nonvented pots. Due to the larger number of lobsters caught in the nonvented traps, more lobsters were injured than in vented traps. Total new damage amounted to 9 percent of the lobsters caught; 42 percent had old damage.

There were 101 instances of major damage to lobsters in our ghost pots, 25 percent occurring within the first 15 days and 69 percent occurring before the 30th day of entrapment. Mortalities amounted to 24.6 percent of the total ghost catch, 30 percent of the mortalities having major injuries prior to their deaths.

There is considerable evidence that the greater part of major damage to lobsters is trap-related. Despite the reputation of lobsters being aggressive, it seems aggression-related injuries in nature may be rare. Scrivener (1971) conducted behavior experiments with 700 pairs of lobsters and never once observed damaging aggression. Writing about decapods, and then his lobsters specifically, he states: "Infrequently fighting leads to physical damage of one individual. This may be rarer under natural conditions for some species, because many of the studies have been done under crowded laboratory conditions. Damaging aggression has occurred among the lobsters in the small holding tanks when the divider has been pushed over but has never been observed in the 6-foot diameter observation tanks."

Stein et al.⁴ conclude that the lobster is much less aggressive than previously thought as long as the lobsters have adequate space and shelter. During their experiments, observing lobster behavior in seminatural habitats in large aquaria, there may have been one or two damage-inducing interactions between lobsters.

We have data showing that many injuries are sustained by lobsters in traps. These injuries are mostly induced by conspecifics in the stress conditions caused by the entrapment. There is also evidence from many sources that on-board handling of traps and lobsters induces injuries. Lobsters roughly handled, such as being dumped into a checker, will open their claws and bite down on the first thing contacted, usually another lobster.

The causes of trap-related mortality are harder to define. Many lobsters probably die directly from the injuries sustained in the traps, i.e., they are cannibalized by healthier lobsters or bleed to death. Lobsters that moult in a trap probably don't stand much of a chance for survival. McLeese (1956) reported that lobsters near moult are less able to withstand stress, thus they may also be subject to mortality in the trap even before moulting.

Toward the end of our Phase III study there were mass mortalities in the ghost traps. One possible cause would have been gaffkemia, a lobster disease. Rabin (1965) found that it is endemic in the natural lobster populations in the Woods Hole area. He also states that virulence may be a condition of the holding impoundment. There are no obvious signs of the disease though it is known to be transmitted through wounds. Higher temperatures speed the progress of the disease (Stewart et al., 1969). It can be shown that when our mass mortalities occurred, conditions were ideal for a gaffkemia epidemic.

Another cause of trap mortality may be predation by other species, especially if the lobsters were recent moults

or weakened by injuries. It is generally considered that healthy hard-shelled lobsters of trapable sizes are not commonly preyed upon. The predator would have to get into the trap and that limits the possibilities further. Scarrott's (1965) work indicates that weakened lobsters confined in traps may be subject to predation by amphipods.

Lobsters probably do not starve to death in traps but may be weakened and stressed by starvation. Morgulis (1916) found that lobsters starved for 56 days showed no outward signs of emaciation and the greatest weight loss was 2.89 percent. The lobsters absorbed water making up for the loss of organic and mineral matter; the weight loss would have exceeded 34 percent otherwise. Stewart et al. (1967) held starved lobsters for 140 days that suffered physiological changes but showed no outward signs of stress or increased cannibalism. McLeese (1956) reported that the lethal limits established for temperature, salinity, and oxygen did not change after 57 days of starvation.

ASSESSMENT OF LOSSES

In this section we will make an assessment of ghost-pot mortality and claw loss for 1976; 1973 through 1975 are similar. The number of traps and lobster landings are preliminary figures gathered by NMFS.

The inshore fishery landed 25,812,000 pounds (11,615,400 kg) using 2,100,000 traps; an annual landings per trap of 12.3 pounds (5.53 kg). The offshore trap fishery landed 4,220,000 pounds (1,899,000 kg) using 72,000 traps; an annual landings per trap of 58.6 pounds (26.4 kg). The annual landings per trap is a rough figure as many traps are only in the fishery for a few months. Another point is that the landings, especially from inshore, represent only a small part of the actual catch, i.e., 20 percent where the throwback ratio is 4 to 1.

Twenty-five percent is presently the most accepted average figure for annual inshore trap loss rate. To see if we could use this figure for the offshore fishery, the port interview data from offshore lobster boats were analyzed.

Port interviews are conducted by

NMFS port agents when a fishing vessel returns from a trip. We surveyed the 1976 interviews from Massachusetts and Rhode Island ports; these two states account for 53,000 of the 72,000 traps being fished offshore. The average vessel fished 400 traps having 25 to 50 traps per trawl. The soak times averaged 4-7 days.

Twenty-nine vessels were listed as fishing 13,040 wood traps. (Many of these vessels fish some wire traps.) One hundred and forty-nine interviews were conducted and a loss of 1,025 pots was reported; a 7.8 percent loss rate.

Eleven vessels fished 4,920 all-metal or plastic pots. During 40 interviews a loss of 121 traps was reported; a 2.4 percent loss rate.

These loss rates at first appear very low but this is due to the fact that many vessels were only interviewed once or twice. We next grouped all vessels that were interviewed six or more times. In this group there were 16 vessels, fishing a total of 7,290 traps, that were interviewed 134 times for an average of 8.3 interviews each. They lost 908 traps for a loss rate of 12.4 percent. From the port weigh-out sheets we determined that these vessels were averaging 20 trips annually so the annual average loss rate was 29 percent. We will use 25 percent for the purposes of this assessment.

Annual inshore trap losses: 525,000 ghost traps.

Annual offshore trap losses: 18,000 ghost traps.

Another category of ghost traps is the cumulative trap losses. From the interview data we found that about one-third of the traps offshore are all-metal or plastic. If we give these traps a 3-year ghost fishing life span, there will be 12,000 additional traps ghost fishing offshore each year. Due to lack of data on inshore trap types lost, we will not evaluate inshore cumulative ghost fishing, but it may be significant.

To determine what the inshore mortality per ghost trap should be, we assumed that half the lobsters in the missing category in our experiments died in the traps. This gives us 0.5 pounds (0.23 kg) per trap in Phase I, 1.3 pounds (0.58 kg) per trap in Phase II, 4.2 pounds (1.9 kg) per trap in Phase III nonvented, and 1.0 pounds (0.45 kg)

⁴Stein, L., S. Jacobson, and J. Atema. 1975. Behavior of lobsters (*Homarus americanus*) in a semi-natural environment at ambient temperatures and under thermal stress. Unpubl. manuscr., 49 p. Woods Hole Oceanogr. Inst. Tech. Rep. 75-48.

per trap in Phase III vented. Annual ghost-trap mortality would be higher for the following reasons: 1) There were lobsters still entrapped at the end of each phase of the experiments. 2) Many of the lobsters were released from our traps when catch escape panels opened and when our traps were raided. 3) Our experiments did not continue into the fall when greater mortality was probable.

We conclude that a conservative figure for the inshore annual ghost-fishing mortality rate would be 2.5 pounds (1.12 kg) per nonvented trap and 1.5 pounds (0.67 kg) per vented (45 mm) trap. (For this assessment we are neglecting legal size differences between states.) We can derive similar figures by taking landings per inshore trap, assume a throwback ratio of 4 to 1 for nonvented traps, and arrive at a catch of 61.5 pounds (27.7 kg) per trap. A ghost trap fishes at 10 percent of this rate (our field experiments) for a ghost catch of 6 pounds (2.7 kg) per trap. Using a 40 percent mortality rate (known mortality plus one-half the missing category) gives us 2.4 pounds (1.1 kg) per nonvented trap.

By an intuitive process we assumed a mortality rate of 6 pounds (2.7 kg) per offshore nonvented trap based on offshore catch rates.

Annual inshore ghost trap mortality: $525,000 \times 2.5 = 1,312,500$ pounds (590,625 kg).

Landed value: \$2,179,000.00 (1976 average price: \$1.66 per pound).

Annual offshore ghost trap mortality: $(18,000 + 12,000) \times 6.0 = 180,000$ pounds (81,000 kg).

Landed value: \$299,000.00.

To assess claw loss we used 10 percent for the number of lobsters with one or more missing or small regenerate claws. We used 15 percent as the weight reduction per cull lobster. Using 30,000,000 pounds (13,500,000 kg) as the annual trap caught landings, we get 450,000 pounds (202,000 kg), for a value of \$747,000.00, lost due to missing and/or regenerate claws.

There are additional losses that cannot be evaluated here. These are the possible decrease in moult frequency and growth increments due to injuries and claw loss sustained in the traps by sublegals.

PREVENTIVE SOLUTIONS

Reduced Effort

It becomes obvious that the best way to reduce trap-related injury and mortality is to reduce the number of traps. Any reduction in the number of traps will cause a corresponding reduction in trap losses and thus in ghost-fishing mortality. If the same landings can be sustained with a 50 percent reduction in traps inshore, then close to 700,000 pounds (315,000 kg) of lobsters will be saved from unprofitable deaths; over \$1.1 million in landed value.

Cutting Losses

It may be possible to decrease pot losses both inshore and offshore substantially below levels of 20-30 percent. To do this the first step needed to be undertaken is a survey to identify quantitatively the causes of pot losses and the methods developed by lobstermen to reduce losses.

As mentioned previously, there are many areas in the lobstering operation that can be improved upon to reduce losses. Trapezoidal pots may be less susceptible to loss than half-round pots. Many lobstermen may be using insufficient ballast or an inferior pot warp. There are indications that some types of buoys are better than others (Spurr, footnote 2, p. 19). Multipot trawls may suffer fewer losses than single pots inshore.

Degradable Sections

To prevent a long-term cumulative ghost fishing problem, the solution might be to have all virtually nondegradable pots contain a section that would rot out in about a year's time. When this section fails it should leave an opening with a minimum dimension at least equal to the diameter of the head opening. The degradable section could consist of wood, natural fiber, or untreated iron wire. As mentioned in the introductory paper (Smolowitz, 1978), this approach has been taken in several fisheries already.

To solve the short-term ghost fishing problem is more difficult. Since the degradable mechanism would be required to fail sooner, it would be more bothersome for the fishermen to keep replacing them. If the fisherman is not fully

convinced of the value of this exercise he may replace the degradable mechanism with a nondegradable one. In the sablefish (blackcod) pot fishery, some fishermen laced up the escape vent with nylon instead of cotton twine.

Sublegal Escape Vents

It has been demonstrated many times that sublegal escape vents reduce the catch of sublegals. Pots that retain fewer lobsters are less destructive to the catch both in the normal and ghost-fishing modes. If all traps inshore used sublegal escape vents of 45 mm, the ghost-catch mortality rate would drop 1.0 pound (0.45 kg) per trap for a saving of 525,000 pounds (236,250 kg), or roughly \$870,000 in landed value. The many additional advantages of sublegal escape vents have already been reviewed elsewhere.

Catch Escape Panels

The sublegal escape vent and the degradable section could be combined into one unit. Our catch escape panel is 8×8 inches (20.3×20.3 cm) and contains a 1¼-inch (45 mm) high ×6-inch (15.2 cm) long sublegal escape vent. This panel is affixed over a 6- ×6-inch (15.2- ×15.2 cm) hole cut into the parlor end of the pot and is attached by two hog-ring hinges on the bottom and a degradable link on the top.

In the closed state the panel allows sublegal-sized lobsters to escape through the vent. After a period of time the degradable link fails, allowing the panel to drop open so all trapped lobsters can escape.

The choice of panel material would probably depend on whether the panel is provided by the State or made by the lobsterman. The choice of degradable link would depend on the failure-time required.

For the purposes of this discussion, we will assume that the panels would be mass-produced by the States, similar to the way auto license plates are, and contain a stamped license number. Lobstermen could, for example, be required to buy one panel annually for each pot fished. Double-parlor pots would be required to have two panels, one on each parlor.

The possible advantages of the catch

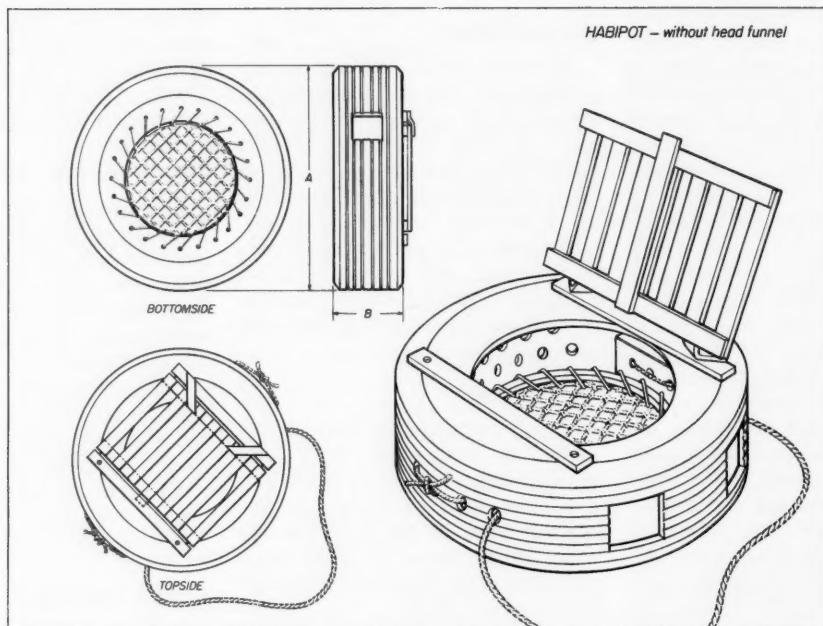


Figure 3.—Basic tire habipot design with two entrance vents and drainage holes. The tires were not negatively buoyant enough and had high drag characteristics during hauling.

escape panel are analyzed in the following discussion.

1. Allows the State to have more accurate knowledge of the number of pots being fished. If the State issues the panels, not only will it have a solid estimate of the number of pots being fished but also of how many are being lost.

2. Easier to enforce regulations due to the high visibility of the panel on the pot. This is one of the major advantages over lath spacing as a means to regulate sublegal catch. All the enforcement officer has to do is to see the panel and he knows it has the correct vent size.

3. Uniform size of sublegal vent allows more accurate control of pot selectivity. The sublegal vent can be accurately sized and constructed so as not to swell or be worn away.

4. Decreases damage to sublegal lobsters. This is an advantage of any sublegal venting mechanism.

5. Decreases illegal sales of sublegal lobsters. This is not known for sure, because many lobsters just under legal size will still be retained. These are the lobsters a dishonest lobsterman would sell.

6. Reduces and eventually ends ghost fishing. A sublegal escape vent, by reducing the number of lobsters retained, should reduce ghost-fishing mortality. When the degradable link fails, the pot will no longer fish.

7. Improves quality of catch. Fewer lobsters in the pot should cause less conspecific-inflicted injuries, e.g., claw loss.

8. Controls bycatch. Pots with sublegal vents let out most crabs. This may be more of a problem where the crabs are sold commercially.

9. Increases pot efficiency. In areas where there is a large population of legal lobsters, the sublegal escape vent should allow more of them to be caught.

Habipots

During this project we constructed and started to test several designs of habipots, but time and money considerations did not allow for completion of the work. Two types of habipots constructed out of old automobile tires (Figs. 3 and 4) were fished with limited success; they caught sublegal lobsters.

A lot more work is necessary to develop a selective nonentrapment type of pot.

CONCLUSIONS

1. The main ghost-fishing danger lies in the cumulative effect on the inshore fishery if the majority of fishermen start using all-metal and/or plastic traps, a trend that is well under way. We recommend that all traps be required to have one untreated wood lath in their construction which, upon rotting out, leaves an opening equal to or greater than 75×150 mm.

2. Any reduction in the total number of traps used will have positive results in reducing ghost fishing and trap-related injuries and mortality even if the fishermen increase effort.

3. We recommend field tests with a 47-mm escape vent, as indications are that this size vent will substantially increase the overall benefits to the fishery attributed to sublegal venting, with only a negligible reduction in legal catch.

4. We recommend that a study be undertaken to determine the causes of trap losses and the means to prevent or reduce them.

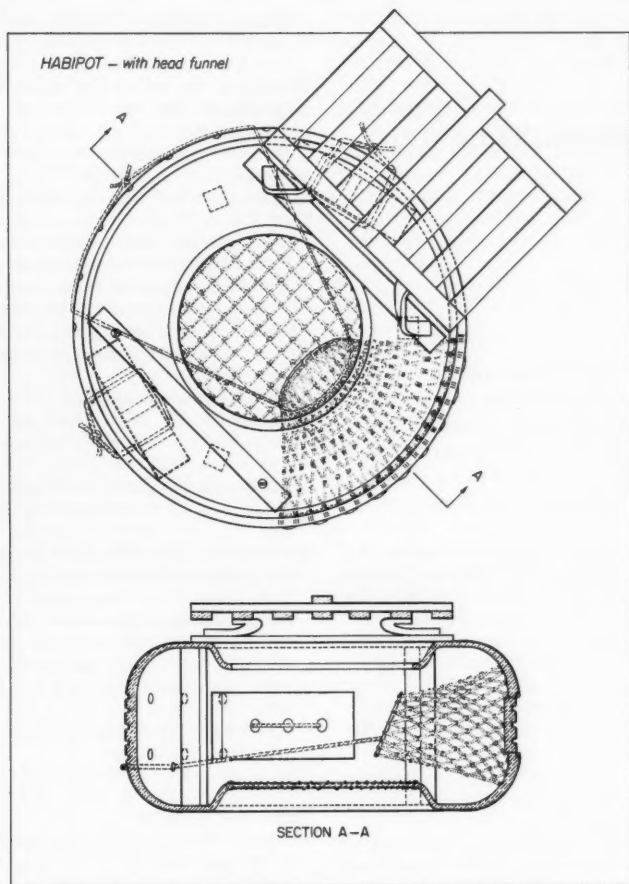


Figure 4.—A head funnel was incorporated into the basic design to prevent escapement during hauling.

5. We recommend that all researchers, where applicable, use a standardized trap to eliminate variable of selectivity and trap efficiency and thus allow for better comparisons of data collected throughout the lobster areas.

ACKNOWLEDGMENTS

Dozens of people were involved in the collection of data used in this report, among them lobstermen, port agents, statisticians, divers, boat operators, and students. Hopefully the authors have done justice to this hard-earned data.

We would like to especially acknowledge John Lamont who performed the near-endless task of preparing the illustrations for this report. Margaret Mehmel also deserves praise for the

tough job of typing the annotated bibliography.

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Annotated Bibliography on Lobster Trapping and Related Subjects

RONALD JOEL SMOLOWITZ

ABSTRACT—This bibliography contains 159 entries that have useful information for those studying lobster trapping. The subjects covered include behavior, general biology, catch statistics, ecology, fishing methods, ghost fishing, management, materials testing, trap design, and selectivity. The brief reviews following each entry are not full abstracts but only serve as a guide to what the reference contains of interest to the trap researcher. The key words serve the same purpose.

Adams, W. C. 1918. Report of the Commission of Fish and Game of Massachusetts for 1918. Public Doc. 25:247-250.

An increase in lobster landings is attributed to the protection of short lobsters. Species: *Homarus americanus*. Key words: behavior, biology.

American Society for Testing and Materials. 1968. 1968 book of ASTM standards, part 24, textile materials—yarns, fabrics, and general methods. Am. Soc. Test. Mater., Phila., 728 p. Standard test methods for yarns and fibers.

Key words: materials testing.

Anonymous. 1959. "Ghost" nets present a novel problem. World Fish. 8(12):21.

The lost gill net problem in the Icelandic cod fishery is briefly reviewed.

Key words: ghost fishing.

_____. 1960. "Ghost" nets that fish years after they are lost. Commer. Fish. Rev. 22(7):46.

One-page article calls attention to the problems of ghost nets fishing for long periods of time after being lost. Bottom-set cod gill nets around Iceland that were recovered after months or years of being lost contained numerous fish skeletons and live fish.

Key words: ghost fishing.

_____. 1961. Fishing methods and gear-gillnets-set. "Ghost" nets retrieved. World Fish. Abstr. 12(1):1.

A short tech note about the recovery of lost gill nets by Iceland's RV *Aegir*. An Icelandic regulation which requires rigging the nets with degradable floatstraps is discussed.

Key words: ghost fishing.

_____. 1970. Rock lobster escape gap report. Southeastern Fisheries Committee, Rock Lobster Research Group, First Meeting, Hobart, Tasmania, 4 p.

Tasmanian research on sublegal escape vents is summarized. Recommended escape vent size is 2¼" H × 12" W. Species: *Jasus novae hollandiae*.

Key words: size regulation, pot selectivity.

Atema, J., and D. G. Engstrom. 1971. Sex pheromone in the lobster, *Homarus americanus*. Nature 232:261-263.

Chemical communication (pheromones) is important in reproductive behavior and may be important in other social communications. Species: *Homarus americanus*.

Key word: behavior.

Atwood, W. G., and A. A. Johnson. 1924. Marine structures: Their deterioration and preservation. Natl. Res. Council, Wash., D.C., 534 p.

Results of studies by the Committee on Marine Piling Investigations of the National Research Council, including reports of test boards in the major harbors of the U.S.

Key words: materials testing.

Bain, J., Jr. 1967. Investigations into the effectiveness of escape gaps in crayfish traps. N.Z. Mar. Dep., Fish. Tech. Rep. 17, Wellington, 20 p.

Trawl strings were set with pots with and without escape gaps. The catch was measured and length frequency histograms were drawn. In one test area the escape gap pots caught significantly fewer shorts without decreasing the legal catch. In another, the entire catch was less in the

escape gap pots. Species: *Jasus edwardsii*.

Key words: pot selectivity.

Bennett, D. B. 1974. The effects of pot immersion time on catches of crabs, *Cancer pagurus* L., and lobsters, *Homarus gammarus* (L.). J. Cons. Int. Explor. Mer 35:332-336.

Daily records of crab and lobster catches off Devon, England, were examined for catch per unit effort in relation to soak time. Lobster CPUE decreased after short periods of soak time but sometimes increased after 4 or more days' soak time. Factors that affect CPUE are listed. Species: *Cancer pagurus*, *Homarus gammarus*.

Key words: catch statistics.

Bickerson, A. W. 1973. Batten pot escape gaps. West. Aust. Dep. Fish Fauna, Fish. Ind. News Serv. 6(1):13.

Escape gap regulations of Western Australia. Species: *Panulirus longipes cygnus*.

Bowen, B. K. 1961. The Shark Bay fishery on snapper (*Chrysophrys unicolor*). Fish. Dep., West. Aust., Rep. 1, 15 p. Snapper fishery information plus some aspects of pot selectivity and "ghost" fishing. Points for and against the use of pots are discussed. Species: *Chrysophrys unicolor*.

Key words: pot selectivity, catch statistics, "ghost" fishing.

_____. 1963. Effectiveness of escape-gaps in crayfish pots. Fish. Dep., West. Aust., Rep. 2, 13 p.

Twenty-five cray pots with different size escape gaps were fished. Carapace length and depth were measured on 1,416 crayfish and length frequencies were tabulated. Correlations were made between carapace depth, escape gap size, and theoretical and actual retention rates of crayfish in the trap selection range. Species: *Panulirus longipes cygnus*.

Key words: pot selectivity, behavior.

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A summary of Western Australian experiments (1963-1965) on escape vents. Species: *Panulirus longipes cygnus*. See also: Bowen, B. K. 1963.

Key words: size regulation, pot selectivity.

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A Norwegian-made plastic lobster and crab pot is briefly described.

Key words: pot design.

Ronald Joel Smolowitz is with the Northeast Fisheries Center, National Marine Fisheries Service, NOAA, Woods Hole, MA 02543.

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Key words: pot design.
- _____. 1969c. Crab trap with anchor. Fish. News (Lond.) No. 2932, 15 August, 6.
Canadian research note on Queen (spider) crab traps indicates that vibrations transmitted by the mooring rope to the trap discouraged crabs from entering. A trap was designed that anchors itself securely to the bottom. Work was done on entrance design.
Key words: pot design.
- _____. 1970. Irish fisherman's ideal lobster pot. Fish. News. (Lond.) No. 2982, 7 August, 6.
Describes a cylindrical wire pot used in the Irish lobster fishery.
Key words: pot design.
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Discusses the problem of chafing on the bottom of plastic lobster pots.
Key words: pot design.
- _____. 1971b. "Traditional" lobster pots can be made of plastic. Fish. News (Lond.) No. 3100, 5 March, 4-5.
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- _____. 1971d. Shellfish traps. Fish. News (Lond.) No. 3036, 27 August, 9-10.
- _____. 1971e. Shellfish traps: a note on what we missed. Fish. News (Lond.) No. 3042, 8 October, 6.
Four-article series lists British pot manufacturers and describes each pot. Many illustrations.
Key words: pot design.
- _____. 1971f. Out on the grounds with a French pot. Fish. News (Lond.) No. 3049, 26 November, 6.
A Scottish fisherman's report on using a Kavel hexagonal top entrance pot.
Key words: fishing methods.
- Castagna, M. 1973. Shipworms and other marine borers. Mar. Fish. Rev. 35(8):7-12.
A brief introduction to marine borers, their classification, description, life history, and distribution.
Key words: materials testing.
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Key words: materials testing.
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A complete report on the status of the Maine lobster fishery as of 1898. Included are a review of the natural history of the lobster, history of the fishery, fishing gear design, fishing methods, marketing, abundance, artificial propagation, and regulations. Species: *Homarus americanus*.
Key words: pot design, fishing methods.
- Cobb, S. J. 1971. The shelter related behavior of the lobster, *Homarus americanus*. Ecology 52:108-115.
The relationship between the lobster and the dimensions and properties of its shelter is reported. Opening dimensions and proportions, overall size, "back door" opening, and light intensity were studied with respect to lobster size groups. Shelter excavation is examined. Species: *Homarus americanus*.
Key words: behavior, ecology.
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An updated review with information on biology, ecology, behavior, the fishery, and aquaculture. (181 references). Species: *Homarus americanus*.
Key words: biology, bibliography.
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Transcript of a convention that discussed whether or not the lobster fishery was in trouble, and if it was, what should be done. The consensus was that the fishery was in a decline due to the increase in fishing effort brought about by improved technology, and the lack of protection of egg-bearing and short lobsters. Discusses regulatory protection of the fishery. Species: *Homarus americanus*.
Key words: size regulation, catch statistics.
- Cope, C. E. 1959. Spiny lobster gear and fishing methods. U.S. Dep. Inter., Bur. Commer. Fish., Fish. Leaf. 487, 17 p.
Current and former gear and methods of the Florida spiny lobster fishery are described and illustrated. Wood and wire pots, ice cans, drums, and hand-held gear are detailed. Gear costs (1959) and selected references are given. Species: *Panulirus argus*.
Key words: fishing methods, pot design.
- DeWolf, A. G. 1974. The lobster fishery of the maritime provinces: economic effects of regulations. Fish. Res. Board Can., Bull. 187, 59 p.
A description of the Canadian lobster fishery, a review of the aspects of lobster biology that affect regulations, a history of Canadian lobster fishery regulations, and a detailed discussion of the economic effects of these regulations. Species: *Homarus americanus*.
Key words: size regulation, catch statistics.
- Dexter, S. C. 1972. Handbook of oceanographic engineering materials, volume 1. Metals and alloys. Woods Hole Oceanogr. Inst., Tech. Memo. WHOI-4-72, 89 p.
A guide for ocean engineers and designers in the selection of materials for use in the marine environment. Includes mechanical, physical, and chemical properties, corrosion resistance, fabricability, availability, and cost.
Key words: materials testing.
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New England's inshore and offshore lobster fishery is surveyed. A brief history of lobster fishing, a detailed discussion of inshore and offshore methods, and the author's view of the future prospects and problems are included. Species: *Homarus americanus*.
Key words: pot design, fishing methods.
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Observations on encounters and the establishment of hierarchies among small groups of adult lobsters were made in test tanks. After initial encounters there was little fighting. Strong males dominated females except in a case where a male was crippled. Species: *Homarus americanus*.
Key word: behavior.
- Dow, R. L. 1961. Some factors influencing Maine lobster landings, parts I-IV. Commer. Fish. Rev., 23(9):1-11. (Also U.S. Fish. Wildl. Serv. Sep. 627, 11 p.)
Four-part article evaluates such factors influencing lobster landings as length of fishing time, catch-per-unit-of-gear, seawater temperature, landed value, and number of pots being fished. Efficiencies of daily and set-over fishing vary with time of year and population size-distribution changes. Species: *Homarus americanus*.
Key words: catch statistics, fishing methods.
- Dow, R. L., F. W. Bell, and D. M. Harri-man. 1975. Bioeconomic relationships for the Maine lobster fishery with consideration of alternative management schemes. U.S. Dep. Commer., NOAA Tech. Rep. NMFS SSRF 683, 44 p.
An extensive review of the Maine lobster fishery and the factors that affect it. In-

- cludes information on life history, growth, mortality, population dynamics, and economic relationships. (Suggests that ghost fishing may be of major significance.) A bioeconomic model of the fishery is presented as is a discussion of past, present, and future management schemes. Species: *Homarus americanus*. Key word: management.
- Dunham, P. J. 1972. Some effects of group housing upon the aggressive behavior of the lobster *Homarus americanus*. J. Fish. Res. Board Can. 29:598-601. Lobsters held 36 days in a group housing tank were less aggressive than lobsters held in individual tanks. There were qualitative differences between the two groups in the aggressive behavior displayed. Species: *Homarus americanus*. Key word: behavior.
- Edwards, E. 1974. Traps used in the British crab and lobster fishery. Fish. News (Lond.) No. 3157, 11 January, 6-7. Brief discussion of the history and reasons for evolution of British trapping gear. Illustrated. Key words: pot design.
- Emmel, V. E. 1905. The regeneration of lost parts in the lobster. Comm. Inland Fish. R.I., 35th Annu. Rep., p. 81-117. This preliminary report on a series of experiments on lobsters to determine the powers of regeneration. From 7 to 25 percent of freshly taken lobsters are missing one or both claws. Species: *Homarus americanus*. Key word: biology.
- . 1906. The relation of regeneration to the molting process in the lobster. Comm. Inland Fish. R.I., 36 Annu. Rep., p. 258-313. Further experiments on the effects of regeneration on the molting process. Regeneration retards molting and increases the length of the period between molts. This effect varies depending on the time the regenerative process is introduced into the molting period. By retarding both the frequency of molting and the increase in size, regeneration retards the rate of growth in the lobster, sometimes by as much as 25 percent. Species: *Homarus americanus*. Key word: biology.
- Ennis, G. P. 1974. Observations on the lobster fishery in Newfoundland. Fish. Res. Board Can., Biol. Stn., St. John's, Tech. Rep. 479, 21 p. The status, trends, and the calculated effects of increasing minimum legal size on the fishery are discussed. Species: *Homarus americanus*. Key words: catch statistics, size regulation.
- Everett, J. T. 1972. Inshore lobster fishing. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Fish. Facts-4, 26 p. Trap design, construction, and buoying methods are presented, along with information on boats, bait, fishing methods, costs, and regulations. This is a revision of Firth's (1944) work on lobster trap design. Species: *Homarus americanus*. Key words: pot design, fishing methods.
- Field, G. W. 1906. The lobster fisheries and the causes of their decline. Comm. Fish. Game, Boston, Mass., 40th Annu. Rep., 46 p. Abstr. The commercial decline of the lobster and its causes is discussed with emphasis on existing and proposed legislation for lobster preservation. Species: *Homarus americanus*. Key words: size regulation, catch statistics.
- . 1911. The lobster fishery: A special report including suggestions for uniform laws made to the legislature of Massachusetts by the Commissioners on Fisheries and Game. Boston, 59 p. Lobster life history is outlined and the fishery status, particularly its decline, causes of decline, and possible solutions, is discussed. The taking and selling of short lobsters is identified as a major factor in the decline. Lath spacing regulations are discussed but not included in a proposed draft of uniform laws. Species: *Homarus americanus*. Key words: size regulation, catch statistics.
- Firth, F. E. 1944. Construction and operation of lobster fishing gear. U.S. Dep. Inter., Bur. Commer. Fish., Fish. Leaflet 64, 14 p. History, construction, and operation of the hoop-net, the half-round pot, and the rectangular lobster pot are covered as are funnels, buoys, bait, and fishing methods. Species: *Homarus americanus*. Key words: pot design, fishery methods.
- Fisheries Agency of Japan. 1958. Illustration of Japanese fishing boat and fishing gear. [In Engl. and Jpn.] Jpn. Assoc. Agric. For., Tokyo, 208 p. Japanese fishery boats and gear are described and illustrated. Topic headings for each piece of gear include construction, operation, fishing season, species, and fishing grounds. A variety of pots and shelter type traps are presented. Key words: pot design, fishing methods.
- Forsyth, W. S. 1960. Lobster and crab fishing. 2nd ed. Adam and Charles Black, Lond., 103 p. Detailed construction methods for netted creels and willow pots along with information on methods of setting and hauling. Species: *Homarus vulgaris*, *Nephrops norvegicus*, *Palinurus vulgaris*, and *Cancer pagurus*. Key words: pot design, fishing methods.
- Gibson, F. A. 1967. Irish investigation on the lobster (*Homarus vulgaris* Edw.). Irish Fish. Invest., Ser. B (Mar.), No. 1. Dep. Agric. Fish., p. 13-45. Annual growth rate, maturity, pathology, and mortality of the lobster, as well as tagging and marking, relationship of size of catch to gear used, and the catch per unit effort, is given. A brief history of Irish lobster fishing is included. Species: *Homarus vulgaris*. Key words: catch statistics, pot selectivity, fishing methods.
- Gibson, F. A., and M. L. Heffernan. 1967. Lobster gear efficiency trials 1966. Dep. Agric. Fish., Leaflet 1, 6 p. American parlor pots, French creels, Scottish creels, and Kilmore Quay pots were fished in several locations off Ireland with different boats and various experimental procedures. Catch per unit effort was recorded along with size and sex data. The American parlor pot caught and retained more lobsters (but fewer sub-legals) than all other traps tested. Species: *Homarus vulgaris*, *Palinurus vulgaris*. Key words: pot selectivity, catch statistics.
- Hancock, D. A. 1974. Attraction and avoidance in marine invertebrates—their possible role in developing an artificial bait. J. Cons. Int. Explor. Mer 35:328-331. Chemical attraction and avoidance reactions in marine invertebrates are discussed in regard to baiting traps. Part relates to the reduction of rock lobster, *Panulirus cygnus* George, catches when dead lobsters are left in the traps. Species: *Panulirus cygnus*. Key word: behavior.
- Harris, D. B. 1972. Corrosion controlled release. Woods Hole Oceanogr. Inst., Tech. Rep. WHOI-72-72, 6 p. Unpubl. manuscript. A low-cost corrosion release device for recovering fish traps using a magnesium-steel galvanic couple is developed. Key words: materials testing.
- Herrick, F. H. 1911. Natural history of the American lobster. Bull. U.S. Bur. Fish. 9:149-408. Extensive coverage of the American lobster, its preservation, and literature. Species: *Homarus americanus*. Key words: bibliography, ecology, fishing methods, size regulation.
- High, W. L. 1976. Escape of Dungeness crabs from pots. Mar. Fish. Rev. 38(4):19-23. Given an opening of sufficient size, Dungeness crabs (*Cancer magister*) will escape from lost traps. Entrance-triggers

- reduce escapement. Octopus predation was observed. Species: *Cancer magister*. Key words: ghost fishing, behavior.
- High, W. L., and A. J. Beardsley. 1971. Observation of fish behavior in relation to fish pots. In J. W. Miller, J. G. VanDerwalker, and R. A. Waller (editors), *Tek-tite 2: Scientists-in-the-Sea*, p. VI-4—VI-14. U.S. Dep. Inter., Wash., D.C.
- Habitat-based scientists studied three trap designs and the reef fish behavior in and around these traps. Territorial defense, social behavior, and predator-prey relationships were observed.
- Key words: pot design, pot selectivity, behavior.
- High, W. L., and I. E. Ellis. 1973. Underwater observations of fish behavior in traps. *Helgolander wiss. Meeresunters.* 24:341-347.
- Diver-scientists noted effects of tunnel design, pot location, bait, set over time, and extended trap leads were observed in three experiments on fish behavior in relation to traps.
- Key words: pot design, pot selectivity, behavior.
- High, W. L., and N. B. Parks. 1973. Timed closing device for fish trap studies. U.S. Dep. Commer., NOAA, Nat. Mar. Fish. Serv., Seattle, 8 p. Unpubl. manuscript.
- Use of commercially available corrosive links for closing fish trap heads to control fishing time during experiments is described.
- Key words: materials testing.
- Himmelfarb, D. 1957. The technology of cordage fibres and rope. *Textile Book Publ.*, Ipswich, Engl., 370 p.
- Fiber characteristics, processing, and the making and finishing of rope is discussed, as are rope properties, protection, and use.
- Key words: materials testing.
- Hipkins, F. W. 1972. Dungeness crab pots. U.S. Dep. Commer., NOAA, Nat. Mar. Fish. Serv., Fish. Facts-3, 13 p.
- Materials and construction methods of Dungeness crab pots are discussed. Pot equipment, fishing techniques, and regulations are also mentioned. Species: *Cancer magister*.
- Key words: pot design, fishing methods.
- Hipkins, F. W., and A. J. Beardsley. 1970. Development of a pot system for harvesting black cod (*Anoplopoma fimbria*). U.S. Dep. Commer., NOAA, Nat. Mar. Fish. Serv., Seattle, 31 p. Prog. Rep.
- Many aspects of fishing gear and techniques used in the development of the experimental pot system are described. Pros and cons of pots including the possibility of ghost fishing are discussed. Species: *Anoplopoma fimbria*.
- Key words: pot design, fishing methods, ghost fishing.
- Hoffman, R. S., P. J. Dunham, and P. V. Kelly. 1975. Effects of water temperature and housing conditions upon the aggressive behavior of the lobster, *Homarus americanus*. J. Fish. Res. Board Can. 32:713-717.
- Lobsters are reported more aggressive at 10°C than at 5°C. Observations on housing conditions VS aggressiveness are discussed. Species: *Homarus americanus*.
- Key word: behavior.
- Hughes, J. T. 1963. Report on the investigation and study of the deep sea lobster fishery. Mass. House Rep. 3190, December 1962, 13 p. Boston.
- This Massachusetts offshore lobster otter trawl fishery survey includes the history of the fishery, a description of the vessels and gear, and the methods used. Species: *Homarus americanus*.
- Key words: fishing methods.
- Isaacson, P. A. 1963. Modifications of Chesapeake Bay commercial crab pot. *Commer. Fish. Rev.* 25(1):12-16.
- This crab pot efficiency study found that placing the entrance heads lower increased catch. One-way gates were effective. Species: *Callinectes sapidus*.
- Key words: pot design, behavior.
- Jaeger, S. 1972. Potfishing and artificial baits symposium proceedings. Wash. Sea Grant Advis. Prog., WSG-AS-72-2, Univ. Wash., Seattle, 32 p.
- Baiting and pot design in the west coast crab and fish pot fisheries. The possibility of ghost fishing was discussed. Species: *Paralithodes camtschatica*.
- Key words: fishing methods, pot design, ghost fishing, behavior.
- Kanciruk, P. and W. F. Herrnkind (editors). 1976. An indexed bibliography of the spiny lobsters, family *Palinuridae*. Fla. Sea Grant Rep. 8. FLSGP-L-76-001. Fla. State Univ., Gainesville, 101 p.
- 1,111 references are indexed by author, key words, subject, and species.
- Key word: bibliography.
- Krouse, J. S. 1976. Incidence of cull lobsters, *Homarus americanus*, in commercial and research catches off the Maine coast. *Fish. Bull.*, U.S. 74:719-724.
- Catch data from 1968-1974 indicate 65 percent of commercially harvested lobsters have lost at least one claw, while 21 percent of the natural population have missing and/or regenerating claws. A relationship is suggested between fishing intensity and the incidence of culls. The loss of value of catch due to culls is quantified. Sublegal escape vents are recommended. Species: *Homarus americanus*.
- Key words: catch statistics, pot selectivity.
- Krouse, J. S., and J. C. Thomas. 1975. Effects of trap selectivity and some population parameters on size composition of the American lobster, *Homarus americanus*, catch along the Maine coast. *Fish. Bull.*, U.S. 73:862-871.
- Information collected aboard Maine commercial lobster boats indicate that throwback ratios of illegal to legal lobsters can be reduced by proper lath spacing. Escape vents of 1 3/4" are recommended for the lobster fishery where the minimum legal length is 81 mm. Species: *Homarus americanus*.
- Key words: pot selectivity, size regulation.
- Leakey, R. D. 1965. Folding traps built to be escape proof. *Natl. Fisherman*, October, p. 13.
- A general discussion of basic principles used in the design of Cornish pots and Scottish creels. The discussion covers construction materials, baiting, and escape proofing of traps. Species: *Homarus vulgaris*, *Palinurus vulgaris*.
- Key words: pot design, fishing methods.
- Lewis, R. D. 1970. A bibliography of the lobsters, genus *Homarus*. U.S. Dep. Inter., U.S. Fish Wildl. Serv., SSRF 591, 47 p.
- A total of 1,303 references are given. Species: *Homarus americanus*, *Homarus vulgaris*, *Homarus gammarus*.
- Key word: bibliography.
- Lund, W. A., L. L. Stewart, and C. J. Rathbun. 1973. Investigation on the lobster. *Comm. Fish. Res. Dev. Act. Final Rep.* 3-130-R, 189 p.
- Extensive report on research performed in the Long Island Sound area covering population structure, ecology, lobster pot distributions, and attempts to locate juvenile lobster concentrations. Included are detailed descriptions of lobster habitats and field measurements of lobster burrow dimensions. A large amount of tagging data and resultant movement information is presented. Species: *Homarus americanus*.
- Key word: ecology.
- McKay, R. J., and R. Worthington. 1936. Corrosion resistance of metals and alloys. Reinhold Publ. Corp., N.Y., 492 p.
- Summarizes information on corrosion processes and rates. Discusses corrosion principles and treats each important metal and some alloys in detail.
- Key words: materials testing.
- McLeese, D. W. 1956. Effects of temperature, salinity and oxygen on the survival of the American lobster. J. Fish. Res. Board Can. 13:247-272.
- A large number of lobsters were tested under a variety of conditions. Lethal limits were established for temperature,

- salinity, and oxygen, and found not to change by size differences (16-34 cm), areas caught, or by starvation up to 57 days. Species: *Homarus americanus*. Key word: biology.
- _____. 1972. Initial experiments on growth of the American lobster in captivity. Fish. Res. Board Can., Biol. Stn., St. Andrews, Tech. Rep. 320, 22 p. Investigates the economic feasibility of growing spring-caught lobsters through a moult (resulting in legal size) in captivity. Results indicate that "better methods are required to eliminate mortality and mutilations, to produce maximum weight increments following a moult, to promote early moulting, and to maintain maximum moulting frequency." Reference is made to cannibalism (p. 5) and claw loss (p. 9) in captivity. Species: *Homarus americanus*. Key word: behavior.
- McLeese, D. W., and D. G. Wilder. 1958. The activity and catchability of the lobster (*Homarus americanus*) in relation to temperature. J. Fish. Res. Board Can., 15:1345-1354. Laboratory experiments were conducted to determine the activity (walking rate) of lobsters acclimated to various temperatures. In addition, experimental fishing data was analyzed and an index of catchability was shown to be linearly related to temperature. The relationship of catchability, temperature, and activity permits the use of catch per unit effort data to estimate lobster populations. Species: *Homarus americanus*. Key words: catch statistics, behavior, pot selectivity.
- McMynn, R. G. 1951. The crab fishery off Graham Island, British Columbia, to 1948. Fish. Res. Board Can., Bull. 91, 21 p. A synopsis of the crab fishery, as stated above, which describes the traps used and contains some comments on mortality, cannibalism, and predation related to the traps. Species: *Cancer magister*. Key words: fishing methods, pot selectivity.
- McRae, E. D. 1960. Lobster explorations on continental shelf and slope off northeast coast of the United States. Commer. Fish. Rev. 22(9):1-7. (Also Sep. 598.) A review of otter trawl exploration cruises of the Delaware in 1955-56. Gear and areas surveyed are covered as well as catch rates of lobsters. Species: *Homarus americanus*. Key words: fishing methods, catch statistics.
- Menzies, R. J. and R. Turner. 1957. The distribution and importance of marine wood borers in the United States. In Symposium on wood for marine use and its protection from marine organisms. Am. Soc. Test. Mater., Spec. Tech. Publ. 200, p. 3-21. Review of 10 major categories of known marine borers and the materials they attack, their use of the material for food, their means of dispersal and to which environments they are adapted. Key words: materials testing.
- Meyer, R. 1973. A study concerning the problem of derelict pots in the king crab, *Paralithodes camtschatica*, fishery. Unpubl. manusc., Kodiak Laboratory, Natl. Mar. Fish. Serv., NOAA, Kodiak, Alaska. This study measured the ability of unbaited pots to retain and capture crabs, and tested the deterioration rate of several pot hanging materials. Deterioration rates of crab ectoskeletons and mortality rates of tagged versus untagged crabs were also tested. Species: *Paralithodes camtschatica*. Key words: ghost fishing, materials testing.
- Meyers, J. J., C. H. Holm, and R. F. McAllister (editors). 1969. Handbook of ocean and underwater engineering. McGraw-Hill, N.Y., 1,094 p. A general handbook covering all aspects of the ocean environment and ocean engineering, including corrosion and marine borers. Key words: materials testing.
- Miller, R. J. 1975. Density of the commercial spider crab, *Chionoecetes opilio*, and calibration of the effective area fished per trap using bottom photography. J. Fish. Res. Board Can. 32:761-768. This paper discusses some aspects of catchability along with its main theme. Species: *Chionoecetes opilio*. Key words: pot selectivity.
- _____. 1976. North American crab fisheries: Regulations and their rationales. Fish. Bull., U.S. 74:623-633. A review of the regulations in six crab fisheries of North America. Ghost fishing and escape vent regulations are mentioned. Key word: management.
- Moody, J. A. 1965. Pilot studies in Saco Bay, Maine, on chemical bait, phototropism, and escape of the American lobster. Bio-Dynamics, Inc., Cambridge, Mass., 16 p. Covers three studies involving the use of trimethylamine as a chemical bait, blue lights as a lure, and escapement of lobsters from conventional pots. Results indicate that trimethylene seems to be a lobster attractor whereas bright or foreign objects do not. Lobsters more readily escape unbaited pots than baited ones. Species: *Homarus americanus*. Key words: pot design, fishing methods, behavior.
- Morgan, G. R. 1973. Effectiveness of rock lobster sorters. West. Aust. Dep. Fish. Fauna, Fish. Ind. News Serv. 6(2):35-36. A short report about an on-deck sorter that was tested as a means to facilitate more rapid sorting and separation of undersize lobsters for both fishing and conservation purposes. Species: *Panulirus longipes cygnus*. Key words: size regulation, fishing methods.
- _____. 1974. Aspects of the population dynamics of the western rock lobster, *Panulirus cygnus* George. II. Seasonal changes in the catchability coefficient. Aust. J. Mar. Freshwater Res. 25(2):249-259. Catchability coefficients were calculated using measurements of catch, effort, population density, and area of reef. The catchability varied significantly and was positively correlated with water temperature and salinity and negatively correlated with premoult condition. It was found that the presence of rock lobster remains in the pot appears to lower catchability. Species: *Panulirus cygnus*. Key words: catch statistics, pot selectivity.
- Morgulis, S. 1916. The influence of fasting on lobsters. Trans. Am. Fish. Soc. 45:188-201. Lobsters starved for 56 days showed no outward signs of emaciation and the greatest weight loss was 2.89 percent. The lobsters absorbed water making up for the weight loss of organic and mineral matter; without this extra water the average weight loss would have exceeded 34 percent. Species: *Homarus americanus*. Key word: biology.
- Munro, J. L. 1973. Large volume stackable fish traps for offshore fishing. Gulf Caribb. Fish. Inst., Proc. 25:121-128. An evaluation of two types of stackable traps. Hexagonal traps (stackable) outfished stackable S-traps but both types were about 25 percent less efficient than traditional traps. Key words: pot design.
- _____. 1974. The mode of operation of Antillean fish traps and the relationships between ingress, escapement, catch, and soak. J. Cons. Int. Explor. Mer 35:337-350. An analysis of ingress and escapement rates versus soak time, pot type, and bait condition, of Antillean fish pots. A simple theoretical model of the mode of operation of fish pots is presented.

- Key words: pot selectivity, catch statistics, behavior, pot designs.
- Munro, J. L., P. H. Reeson, and V. C. Gaut. 1971. Dynamic factors affecting the performance of the Antillean fish trap. *Gulf Carribb. Fish. Inst., Proc.* 23:184-194.
- Extensive diver observations of the catch rates of Antillean fish pots. Comparisons are made on the composition of the catch, effects of lunar periodicity, catch per day soaked, conspecific attraction, effect of bait, and the fate of lost pots.
- Key words: pot selectivity, behavior, ghost fishing.
- National Marine Fisheries Service. 1971. Exploratory fishing and gear research base. Shellfish resource assessment. Cruise Rep., R/V *Delaware II* 70-8. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Woods Hole, Mass., 10 p.
- The cruise was concerned with evaluating equipment used to gather biological information and samples as well as evaluating resources available. Results include a compression of fishing effort by location, based on the different types of pots used, and also depth ranges by location of the various crustacea caught. Species: *Homarus americanus*, *Geryon quinquequedens*, *Cancer borealis*.
- Key words: fishing methods, pot design, catch statistics.
- _____. 1972. Fishery statistics of the United States 1969. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Stat. Dig. 63, 474 p.
- Contains statistical data on the American lobster fishery, by state (landings, value, and gear).
- Key words: catch statistics.
- _____. 1973. Fishery statistics of the United States 1970. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Stat. Dig. 64, 489 p.
- Contains statistical data on the American lobster fishery, by state (landings, value, and gear).
- Key words: catch statistics.
- _____. 1974. Fishery statistics of the United States 1971. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Stat. Dig. 65, 424 p.
- Contains statistical data on the American lobster fishery, by state (landings, value, and gear).
- Key words: catch statistics.
- _____. 1975. Fishery statistics of the United States 1972. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Stat. Dig. 66, 517 p.
- Contains statistical data on the American lobster fishery, by state (landings, value, and gear).
- Key words: catch statistics.
- _____. 1976. Fishery statistics of the United States 1973. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Stat. Dig. 67, 458 p.
- Contains statistical data on the American lobster fishery, by state (landings, value, and gear).
- Key words: catch statistics.
- New England Marine Resources Information Program. 1972. Forget the mice! It's a better lobster trap that's needed. NEMRIP Inf. 34, Univ. R.I., p. 1-2.
- Brief discussion of offshore trap design covering NMFS experiments with metal traps.
- Key words: pot design.
- Nowak, W. S. W. 1972. The lobster (Homaridae) and the lobster fisheries: an interdisciplinary bibliography. Tech. Rep. 6, Mar. Sci. Res. Lab. Mem. Univ. Newfoundland, 313 p.
- 3,217 references listed alphabetically with a subject index.
- Key word: bibliography.
- Nye, W., Jr. 1887. A reasoning lobster. Bull. U.S. Fish Comm. for 1886. 6:186.
- A short note about a lobster apparently using reason to avoid capture while stealing bait from a snare-type trap. Species: *Homarus americanus*.
- Key word: behavior.
- O'Farrell, R. C. 1966. Lobsters, crabs, and crawfish. Fish. News (Books) Ltd., Lond., 120 p.
- O'Farrell, a British inshore fisherman, discusses all aspects of lobstering, drawing upon existing scientific knowledge and practical experience. Species: *Homarus vulgaris*.
- Key words: pot design, behavior, fishing methods.
- Peterson, S. B., and J. M. Friedman. 1977. The Massachusetts lobster fishery: Model legislation and management plans. Woods Hole Oceanogr. Inst. Tech. Rep. 77-5, 81 p. Unpubl. manuscript.
- Presents four possible management plans and five statutes for imposing the plans. Trap tags and gear limits are among the suggestions. The results of a questionnaire completed by Massachusetts lobstermen are discussed. Species: *Homarus americanus*.
- Key word: management.
- Pontecorvo, G. 1962. Regulation in the North American lobster fishery. FAO Fish. Rep. 5:239-297.
- Discusses the biology and geography of the fishery as well as a history of present-day regulations. The author calls for more biological and economic research. Species: *Homarus americanus*.
- Key words: size regulation.
- Prudden, T. M. 1962. About lobsters. Bond Wheelwright Co., Freeport, Maine, 170 p.
- A practical book that discusses lobsters and the lobster fishery of the New England inshore waters. Coverage includes lobster ecology, biology, fishing methods, holding and transport, and marketing. Species: *Homarus americanus*.
- Key words: fishing methods, pot design, behavior, ecology.
- Rabin, H. 1965. Studies on gaffkemia, a bacterial disease of the American lobster, *Homarus americanus* Milne-Edwards. J. Invertebr. Pathol. 7:391-397.
- Contains a study of the local distribution of *Gaffkya homari* in the Woods Hole, Massachusetts, area. Thirty-two percent of a sample from the Marine Biological Laboratory's supply of recently caught lobsters were found infected. There were no obvious external signs of the disease. Species: *Homarus americanus*.
- Key word: biology.
- Rathbun, R. 1887. The crab, lobster, crayfish, rock lobster, shrimp, and prawn fisheries. In George Brown Goode (editor), The fisheries and fishery industries of the United States. Sec. V, Vol. II, p. 627-810. Gov. Print. Off., Wash., D.C.
- Part XXI of this volume contains an historical background of the lobster fishery, the gear in use, and the regulations.
- Ritchie, L. D. 1966. Crayfish pot escapement gap survey, November 1965-January 1966. N.Z. Mar. Dep., Fish. Tech. Rep. 14, Wellington, 24 p.
- Experiments were conducted at four different locations along the New Zealand coast using various types of pots with and without escape vents. The report discusses the practicability of escape gaps, effect of variation of escape gap size, conditions affecting the escape of small crayfish, and the effect of escape gaps on catch-length frequencies. Results indicate that escape gaps are effective and that their effectiveness depends on the total escape gap area, the amount of bait used and the time required for consumption, the pot set time, and the size composition of the fished population. Species: *Jasus edwardsii*.
- Key words: pot selectivity, catch statistics, size regulation.
- _____. 1970. Southern spider crab (*Jacquiniotia edwardsii* Jacquiniot 1853) survey—Auckland Islands and Campbell Island. N.Z. Mar. Dep., Fish. Tech. Rep. 52, Wellington, 111 p.
- This report contains data on comparison fishing crab pots with and without escape gaps. Crab biology and processing are

also discussed. Species: *Jacquiniotia edwardsii*.
Key words: catch statistics, pot selectivity.

_____. 1972. Octopus predation on pot-caught rock lobster—Hokianga area, N.Z., Sept.-Oct. 1970. N.Z. Mar. Dep., Fish. Tech. Rep. 81, Wellington, 40 p. Data were collected to determine the effect of escape gaps on octopus predation of lobsters in pots. These data also include the effect of fishing period, size of pot, and location fished. The relationship of these variables, the loss of revenues to the fishermen, and control measures are reviewed. Losses are estimated at \$30 per boat per day. Escape gap pots were visited by fewer octopuses, caught more legal lobsters, and did not retain as many octopuses as non-escape pots. This last point is of negative value since one way to deal with the predation problem is to develop an incidental octopus fishery. One solution presented is to relocate the escape gap higher up the sides of the pot, thus retaining more octopuses for sale. Species: *Jasus edwardsii*.
Key words: pot selectivity, catch statistics, pot design, behavior.

Rivers, J. B. 1966. Gear and technique of the sea bass trap fishery in the Carolinas. Commer. Fish. Rev. 28(4):15-20. (Also Sep. 761.)
Baited pots are used by fishermen in the Carolinas to commercially produce black sea bass. The methods used are dissimilar to those used in New Jersey. One of the major differences is that in New Jersey pots are fished unbaited while in the Carolinas the sea bass are attracted to the pots for food rather than shelter. Species: *Centropomus striata*.
Key words: pot design, fishing method.

Robinson, L. A. (editor). 1977. Fisheries of the United States, 1976. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv. Curr. Fish. Stat. 7200, 96 p. Contains statistical data on lobster landings, supply, value, and volume, as well as import statistics.
Key words: catch statistics.

Rutherford, J. B., D. G. Wilder, and H. C. Frick. 1967. An economic appraisal of the Canadian lobster fishery. Fish. Res. Board Can., Bull. 157, 126 p. Contains some discussion on the merits and demerits of size limits and gear regulations as management tools. Other sections review the history of the Canadian lobster fishery, effort and output, lobster biology, fishing methods, and economic theory and management of the lobster fishery. Species: *Homarus americanus*.
Key words: size regulation, fishing methods, catch statistics.

Scarrett, D. J. 1965. Predation on lobsters (*Homarus americanus*) by *Anonyx* sp. (Crustacea, Amphipoda). J. Fish. Res. Board Can. 22:1103-1104.

A short report on observations of live lobsters being consumed by amphipods. It seems that healthy lobsters can resist attack by amphipods except where movement is restricted as in lobster crates. Species: *Homarus americanus*.
Key word: biology.

_____. 1973. Claw loss and other wounds in commercially caught lobsters (*Homarus americanus*). J. Fish. Res. Board Can. 30:1370-1373.

Pot-caught lobsters were found to have an incidence of claw loss ranging from 5 to 19 percent though no specific causes were identified. Rough handling, moving fishing gear, ice in shallow waters, and behavioral interactions are thought to be contributing factors. Incidence of other wounds ranged between 1 and 11 percent in the lobsters sampled. Species: *Homarus americanus*.
Key words: catch statistics, fishing methods, behavior.

Schroder, W. C. 1959. The lobster, *Homarus americanus*, and the red crab, *Geryon quinquedens*, in the offshore waters of the western north Atlantic. Deep-Sea Res. 5:266-282.
Describes the development of the offshore otter trawl fishery for lobsters in detail giving many catch statistics. A limited amount of similar data are presented on the red crab. Commercial fishing log-book data are included in an appendix. Species: *Homarus americanus*, *Geryon quinquedens*.
Key words: catch statistics, fishing methods.

Scrivener, J. C. E. 1971. Agonistic behaviour of the American lobster, *Homarus americanus* (Milne-Edwards). Fish. Res. Board Can., Tech. Rep. 235, 128 p.

An extensive study of agonistic behavior patterns in lobsters. An ethogram of agonistic behaviors and a scheme of behavioral sequence pathways are presented. Species: *Homarus americanus*.
Key word: behavior.

Seaman, W., Jr., and D. Y. Aska (editors). 1974. Research and information needs of the Florida spiny lobster fishery. Proceedings of a conference held March 12, 1974, Miami. Mar. Adv. Program, Univ. Fla., Gainesville, SUSF-SG-74-201, 64 p.

Contains 11 papers on the spiny lobsters, covering biology, ecology, fishing methods, catch statistics, and economics data. An appendix on Florida's lobster management program includes a regulation aimed at preventing ghost fishing (p. 58). Species: *Panulirus argus*.

Key words: fishing methods, ghost fishing.

Sheehy, D. J. 1976. Utilization of artificial shelters by the American lobster (*Homarus americanus*). J. Fish. Res. Board Can. 33:1615-1622.

Two types of artificial shelters were fabricated of concrete and placed near Point Judith, Rhode Island, in areas devoid of natural shelter. It was found that spacing and orientation had significant effects on occupancy. Lobster abundance on the shelter sites equaled or exceeded those reported for good natural grounds. Species: *Homarus americanus*.
Key word: behavior.

Sheldon, W. W., and R. L. Dow. 1975. Trap contributions to losses in the American lobster fishery. Fish. Bull., U.S. 73:449-451.

A note on studies to evaluate ghost traps in Maine waters from July 1971 to June 1973. Authors conclude that approximately one-third of lobster in or entering unbaited traps will be lost to the fishery from cannibalism or retention. Species: *Homarus americanus*.
Key words: ghost fishing.

Skud, B. E., and H. C. Perkins. 1969. Size composition, sex ratio, and size at maturity of offshore northern lobsters. U.S. Dep. Inter., Bur. Commer. Fish., Spec. Sci. Rep. Fish. 598, 10 p.

Data for the report were obtained from samples taken from five submarine canyons, selected for reasons of commercial importance and geographic separation, between 1965 and 1967. Data were tabulated by canyon area according to size and sex. Conclusions were drawn pertaining to size and size distribution with respect to depth, sex ratio, number of egg bearing lobsters, moulting season, and female maturity. Mention was made of the increasing role of offshore trawl fishing for lobster. Species: *Homarus americanus*.
Key words: catch statistics, fishing methods, biology.

Smith, F. G. W. 1958. The spiny lobster industry of Florida. Fla. Board Conserv., Educ. Ser. 11, 36 p.

This report defines and discusses the spiny lobster and its life history. Emphasis is placed on fishing techniques, legal requirements, and the value of the spiny lobster industry. Species: *Panulirus argus*.
Key words: biology, fishing methods.

Smith, G. F. M. 1944. The catchability of lobsters. J. Fish. Res. Board Can. 6:291-301.

The returns from tagging over 6,000 lobsters were analyzed mathematically for information on lobster catchability in the commercial pot fishery. Results indi-

- cate that the difference in catchability between large and small lobsters is greatest when the mean length is small and the population density is high. Large lobsters are more catchable than small ones. Catchability is affected by moulting, pot type, and the amount of fishing effort applied. Some conclusions can be made in estimating population sizes using the techniques of the author. Species: *Homarus americanus*.
Key words: catch statistics, size regulation, pot selectivity.
- Spurling, T. S. 1968. How to build a successful wire lobster trap. Natl. Fisherman, March, 48:11-B.
An article by a fisherman on how to build one type of all-wire inshore trap. He reports that his traps can go four years without repair and are more resistant to storm damage than wood traps. He also states that sea urchins eat out the nylon heading on traps. Species: *Homarus americanus*.
Key words: pot design.
- Spurr, E. 1972. Lobster research project: Final report of 3-105-R, July 1969-June 1971. Fish. Div., N.H. Fish Game Dep., 22 p. Unpubl. rep.
This project was divided into five jobs, one of which was comparison fishing of lobster pots. The other jobs include the collection of effort, hydrographic, and tagging data. Experiments suggest that parlor head design is an important factor in pot efficiency. Wire covered traps moved less than wood-lath covered traps. Species: *Homarus americanus*.
Key words: pot design, catch statistics.
- Stasko, A. B. 1975. Modified lobster traps for catching crabs and keeping lobsters out. J. Fish. Res. Board Can. 32:2515-2520.
Laboratory and field experiments were conducted to develop a trap for capturing crabs, *Cancer irroratus*, and excluding lobsters, *Homarus americanus*. Different size and shaped entrances and escape holes were tested. A long rectangular opening, 44.5 mm wide, allowed most crabs to enter yet prevented passage of most legal-size lobsters. Round openings were more effective than square ones to allow escape of lobsters and retention of commercial-size crabs. Species: *Cancer irroratus*, *Homarus americanus*.
Key words: pot design, pot selectivity.
- Stein, L., S. Jacobson, and J. Atema. 1975. Behavior of lobsters (*Homarus americanus*) in a semi-natural environment at ambient temperatures and under thermal stress. Woods Hole Oceanogr. Inst. Tech. Rep. 75-48, 49 p. Unpubl. manuscript.
Two 10-foot diameter aquaria were established as semi-natural habitats for a number of lobsters and other animals. Observations were made on shelter selection, feeding, activity, and social behavior. It was found that aggression was most frequent during feeding; cohabitation between males and females occurred for several days following mating; and the frequency of aggressive behavior in the temperature range 22-28°C was similar to levels at ambient temperatures. There were very few aggressive interactions between lobsters. Species: *Homarus americanus*.
Key word: behavior.
- Stewart, J. E. 1975. Gaffkemia, the fatal infection of lobsters (genus *Homarus*) caused by *Aerococcus viridans* (var.) *homari*: A review. Mar. Fish. Rev. 37(5-6):20-24.
A review of gaffkemia, mentioning the effects of temperature and salinity on rate of death. Twenty-four references listed. Species: *Homarus americanus*.
Key word: biology.
- Stewart, J. E., J. W. Cornick, D. I. Spears, and D. W. McLeese. 1966. Incidence of *Gaffkemia homari* in natural lobster (*Homarus americanus*) populations of the Atlantic region of Canada. J. Fish. Res. Board Can. 23:1325-1330.
Hemolymph samples from 2,035 lobsters demonstrated that *G. homari* is widespread in the Canadian Atlantic area. Incidence levels vary with area and possibly time. Species: *Homarus americanus*.
Key word: biology.
- Stewart, J. E., J. W. Cornick, D. M. Foley, M. F. Li, and C. M. Bishop. 1967. Muscle weight relationship to serum proteins, hemocytes, and hepatopancreas in the lobster, *Homarus americanus*. J. Fish. Res. Board Can. 24:2339-2354.
Serum protein values, hemocyte numbers, and muscle weights were determined for 216 lobsters immediately after capture and 230 lobsters held captive under several dietary and environmental conditions. Diet was found to be more important than temperature in changing muscle and serum protein values. Mortality rate was the same for both fed and starved lobsters held for 140 days. Starved animals showed no obvious signs of stress, lessened activity, or increased cannibalism. Species: *Homarus americanus*.
Key word: biology.
- Stewart, J. E., J. W. Cornick, and B. M. Zwicker. 1969. Influence of temperature on gaffkemia, a bacterial disease of lobster, *Homarus americanus*. J. Fish. Res. Board Can. 26:2503-2510.
The mean time to death in lobsters infected with gaffkemia is lower at higher temperatures. Species: *Homarus americanus*.
Key word: biology.
- Stewart, J. E., G. W. Horner, and B. Arie. 1972. Effects of temperature, food, and starvation on several physiological parameters of the lobster *Homarus americanus*. J. Fish. Res. Board Can. 29:439-442.
Data are presented on the effects of temperature and starvation on a number of physiological parameters. Species: *Homarus americanus*.
Key word: biology.
- Stewart, J. E., and H. J. Squires. 1968. Adverse conditions as inhibitors of ecocysis in the lobster *Homarus americanus*. J. Fish. Res. Board Can. 25:1763-1774.
Lobsters were tested under several conditions to note the effect on moulting incidence. A reduction in moulting was achieved by enforcing a high degree of association between lobsters. Darkness and starvation under highly restrictive conditions inhibited moulting the most of all conditions tested. Species: *Homarus americanus*.
Key words: biology, behavior.
- Stewart, R. 1971. A living from lobsters. Fish. News (Books) Ltd., Lond., 67 p.
This book, written by a British lobsterman, discusses aspects of lobstering including creel design, lobster behavior, fishing strategy, and boat selection. Species: *Homarus vulgaris*.
Key words: fishing methods, pot design, behavior.
- Struhsaker, P., and D. C. Aasted. 1974. Deepwater shrimp trapping in the Hawaiian Islands. Mar. Fish. Rev. 36(10):24-30.
Discusses exploratory trap fishing for *Penaeus marginatus*, *Heterocarpus ensifer*, and *H. laevigatus*. A variety of trap types were tried with variations in baiting and head design. The authors note a problem with cannibalism among *H. ensifer*; the highest rates occurring with long set-overs or in traps where the bait was gone. Species: *Penaeus marginatus*, *Heterocarpus ensifer*, *H. laevigatus*.
Key words: pot design, pot selectivity.
- Templeman, W. 1939. Investigations into the life history of the lobster (*Homarus americanus*) on the west coast of Newfoundland, 1938. Newfoundland Dep. Nat. Resour., Fish. Bull. 7, 52 p.
Covers aspects of the life history of the Newfoundland lobster such as average sizes, sex ratios, moulting, pot selectivity, egg laying and hatching, and larval distributions. Pot selectivity experiments were also carried out. Species: *Homarus americanus*.

Key words: catch statistics, biology, pot selectivity.

- _____. 1958. Lath-spacing in lobster traps. Fish. Res. Board Can., Prog. Rep. Atl. Coast Stn. 69:22-28.
A review of Canadian experiments concerned with lath-spacing and the Canadian laws that evolved from them. Species: *Homarus americanus*.
Key words: size regulation, pot selectivity.
- Thomas, H. J. 1953. The efficiency of fishing methods employed in the capture of lobster and crabs. J. Cons. Int. Explor. Mer 18:333-350.
Comparison fishing was performed using four types of creels, one standard and three modified. Additional comparison was made between creels and scoop nets. Comparison fishing showed that fewer crabs were caught in the single-eyed creel and that more lobsters and crabs were caught in the finer-mesh creel. Scoop nets proved less size-selective than creels. The significance of the results in the estimation of population statistics is discussed. Species: *Homarus vulgaris*, *Cancer pagurus*.
Key words: pot design, pot selectivity, catch statistics.
- _____. 1954. The efficiency of the Cornish pot and the Scottish creel in the capture of lobsters and crabs. J. Cons. Int. Explor. Mer 20:87-91.
Twenty-four Cornish pots were fished against the same number of Scottish creels. Results show that under specified fishing conditions the difference in catching power between the two types of pots was negligible. There was no significance in number or size of lobsters caught even when the Cornish pots used three times as much bait as the Scottish creels. Species: *Homarus vulgaris*, *Cancer pagurus*.
Key words: pot design, catch statistics.
- _____. 1959. A comparison of some methods used in lobster and crab fishing. Scott. Fish. Bull. 12:3-8.
Discusses different types of pots with respect to size, shape, construction materials, and the effects of variables such as eye construction, escape preventers, bait, and areas being fished. Suggestions are provided for improving the fishing capability of pots. Species: *Homarus vulgaris*, *Cancer pagurus*.
Key words: pot design, fishing methods.
- Thomas, J. C. 1973. An analysis of the commercial lobster (*Homarus americanus*) fishery along the coast of Maine, August 1966 Through December 1970. U.S. Dep. Commer., NOAA Tech. Rep. NMFS SSRF-667, 57 p.
Life history information as well as catch and effort data are evaluated to determine

the optimum minimum legal size for maximum sustainable yield for the State of Maine. Recommendations include raising the minimum size of lobsters to 89 mm (carapace length) and eliminating Maine's maximum size regulations. The author feels pot limitations will not effectively diminish fishing effort but that lath-spacing may be a means to increase overall yields. Species: *Homarus americanus*.

- Key words: catch statistics, pot selectivity, biology, size regulation.
- Todd, J. H., D. Engstrom, S. Jacobson, and W. O. McLarney. 1972. An introduction to environmental ethology: A preliminary comparison of sublethal thermal and oil stresses on the social behavior of lobsters and fishes from a freshwater and marine ecosystem. Woods Hole Oceanogr. Inst. Tech. Rep. 72-42, 104 p. Unpubl. manuscript.
Contains a discussion of stress related to animal behavior and environment. The section on lobsters is an overview of pilot experiments on the influences of temperature and kerosene on feeding, social behavior, and organization. Species: *Homarus americanus*.
Key word: behavior.
- Tuthill, A. H., and C. M. Schillmoller. 1966. Guidelines for selection of marine materials. Int. Nickel Co., N.Y., 37 p.
A review of the performance of carbon steel in marine service and the major corrosion factors to be taken into consideration when using more durable materials. Key words: materials testing.
- Uhlig, H. H. (editor). 1948. The corrosion handbook. John Wiley and Sons, N.Y., 1,188 p.
A condensed summary of corrosion information, including scientific data and industrial experience, with emphasis on quantitative information.
Key words: materials testing.
- Uhlig, H. H. 1963. Corrosion and corrosion control. John Wiley and Sons, N.Y., 371 p.
An introduction to the underlying science of corrosion and to the fundamentals of corrosion engineering.
Key words: materials testing.
- U.S. Fish and Wildlife Service. 1968a. Exploratory fishing and gear research base. Lobster explorations on the continental slope and shelf with pot (trap) fishing gear. Cruise Rep., M/V Delaware 68-3. U.S. Dep. Inter., Bur. Commer. Fish. Gloucester, Mass., 8 p.
First report of a series of cruises scheduled to investigate pot fishing for lobsters on the continental shelf and slope. Report includes gear and gear handling, as well as fishing results.

Species: *Homarus americanus*, *Geryon quinquedens*, *Cancer borealis*.

- Key words: fishing methods, pot design, catch statistics.
- U.S. Fish and Wildlife Service. 1968b. Exploratory fishing and gear research base. Lobster explorations with pot (trap) gear. Cruise Rep., M/V Delaware 68-5. U.S. Dep. Inter., Bur. Commer. Fish., Gloucester, Mass., 7 p.
This was the second cruise by the M/V Delaware to investigate offshore pot fishing. Attention was given to the retrieval of the equipment lost on the first cruise. Exploratory fishing was also tried in the shoal waters of the Gulf of Maine and Georges Bank. Species: *Homarus americanus*, *Geryon quinquedens*, *Cancer borealis*.
Key words: fishing methods, catch statistics, ghost fishing.
- University of Rhode Island. 1972. Marine economics data: 80-foot Point Judith lobster vessel (wood VS wire pots). Mar. Memo. 14, URI Mar. Advis. Serv., Narragansett, 2 p.
A cost comparison between using wood and wire pots on an offshore lobster vessel. Species: *Homarus americanus*.
Key words: fishing methods, pot design.
- Van Dorb, W. G. 1950. An automatic marine time release device. Scripps Inst. Oceanogr., Oceanogr. Rep. 22, 5 p.
Discusses timing device for release of bottom-anchored equipment using a magnesium link.
Key words: materials testing.
- Van Engel, W. A. 1962. The blue crab and its fishery in Chesapeake Bay. Part 2—types of gear for hard crab fishing. Commer. Fish. Rev. 24(9):1-10.
Presents the history and development of the blue crab gear used in the Chesapeake Bay area. Contains a good section on the pot's development. The author states there is greater than 100 percent annual pot losses in the fishery. Life expectancy of a pot worked daily is about 16 weeks due to wear and corrosion. Twenty-one references cited. Species: *Callinectes sapidus*.
Key words: pot design.
- Von Brandt, A. 1964. Fish catching methods of the world. Fish. News Ltd., Lond., 191 p.
This book is an encyclopedia of information about fish catching techniques and equipment from the oldest and most primitive to the modern. A variety of traps and pots are illustrated. There is a brief discussion of ghost fishing of gill nets on page 168.
Key words: pot design, ghost fishing.
- Wilder, D. G. 1944. The effect of lath spac-

ing and the size of fishing ring on the catch of lobster traps. Fish. Res. Board Can., Prog. Rep. Atl. Coast Stn. 34:22-24.

Comparison of catches between pots with 5" fishing rings, 1 1/4" lath spacing, and pots with 4" rings and 3/4" spacing. Wider space pots have greater increases in catch where the average size of lobsters caught is large. Where the average size is small the percentage reduction in captured shorts is greatest. Wide lath pots caught favor crabs. Species: *Homarus americanus*.

Key words: pot selectivity, catch statistics.

_____. 1945. Wider lath spaces protect short lobsters. Fish. Res. Board Can., Atl. Biol. Stn., Circ. 4, 1 p.

A circular produced for fishermen advocating the use of 1 1/4" lath spacing where the minimum size regulation is set at 7" overall. Advantages of this spacing include catching less shorts and more legal-sized lobsters, less crabs, and having a lighter pot that needs less ballast. Species: *Homarus americanus*.

Key words: size regulation, pot selectivity.

_____. 1948. The protection of short lobsters in the market lobster areas. Fish. Res. Board Can., Gen. Ser. Circ. 11, 1 p. Circular advocates the use of 1 1/4" lath spaces when the legal minimum size is 3 1/2" carapace length. Contains experimental data on escapement of shorts. Species: *Homarus americanus*.

Key words: size regulation, pot selectivity.

_____. 1949. Protect short lobsters by widening lath spaces. Fish. Res. Board Can., Gen. Ser. Circ. 14, 1 p.

A circular similar to G-4 (Wilder, 1945), advocating 1 1/4" lath spacing for pots used to catch lobsters 7" overall length and greater. Has experimental data indicating 1 1/4" lath spacing allows 60 percent of the shorts to escape. Species: *Homarus americanus*.

Key words: size regulation, pot selectivity.

_____. 1954. The lobster fishery of the southern Gulf of St. Lawrence. Fish. Res. Board Can., Atl. Biol. Stn., Gen. Ser. Circ. 24, 16 p.

The paper contains a review of the life history of the lobster with special emphasis on the southern Gulf of St. Lawrence stocks. Regulations pertaining to closed seasons, berried lobsters, size limits, and lath spacing are discussed. A biological analysis is conducted on how a change in a regulation might affect the fishery. Species: *Homarus americanus*. Key words: size regulation, biology, pot selectivity.

_____. 1956. Experiments to improve lobster traps. Fish. Res. Board Can., Biol. Stn., St. Andrews, New Brunswick. Unpubl. manuscript.

Standard wooden pots were compared against nine types of pots constructed of steel, aluminum, and cotton mesh. Three types were made almost entirely of aluminum; one of these was made of galvanized sheet iron, and one of plastic. Large variations in catches between the different experiments. Variables include type of pot, season of year, size of openings, and how pot lands on bottom. Steel traps showed higher resistance to damage during storms. Species: *Homarus americanus*. Key words: pot design.

_____. 1962. Lobster conservation in Canada. Special meeting on crustacea, No. 10. Int. Counc. Explor. Sea, 9 p.

The report covers the history and effects of fishing seasons, size limits, protection of egg-bearing females, lath spacing regulations, and hatcheries on the Canadian lobster resource. Available data indicates that lobster landings (by weight) have not been significantly affected by regulations defining fishing seasons, outlawing egg-bearing lobster sales, and specifying minimum sizes. Wilder believes environmental factors are more important in determining the sustained yield but that the regulations have important economic and sociological effects. Species: *Homarus americanus*.

Key word: management.

_____. 1967. Lobster conservation in Canada. Fish. Res. Board Can., Stud. No. 1039. In 1966 Studies (Part II):237-245.

A review and discussion of Canadian regulations covering fishery seasons, size

limits, trap lath spacing, and hatcheries. Species: *Homarus americanus*.

Key word: management.

Wilder, D. G., and U. J. Walsh. 1968. TBTO—A safe, effective treatment for lobster traps. Fish. Res. Board Can., Gen. Ser. Circ. 53, p. 22.

A short note indicating that traps treated with TBTO successfully resist attack by wood borers, *Teredo navalis*.

Key words: materials testing.

Winstanley, R. H. 1970. Escape gap commercial crayfishing trials. Prof. Fisherman's Assoc. Tasmania (magazine), April, p. 118.

Short article gives details of a comparison fishing experiment between pots fitted with escape vents of different sizes and pots without vents. Species: *Jasus novae hollandiae*.

Key words: size regulation, pot selectivity.

_____. 1971. Southern rock lobster carapace length-depth relationship. Fish. Div., Dep. Agric., Hobart, Tasmania, 3 p.

Report of a study made of the relationship between carapace length and depth of the southern rock lobster with reference to escape gap research. Species: *Jasus novae hollandiae*.

Key words: size regulation, pot selectivity.

_____. 1973. Tasmanian rock lobster fishery—past and future. Aust. Fish. 32(7):15-20.

A review of the history and development of the fishery, discussing possible implications of different management schemes, including escape vents. Species: *Jasus novae hollandiae*.

Key words: catch statistics, biology, fishing methods, size regulation.

Wolf, R. S., and G. R. Chislett. 1974. Trap fishing explorations for snapper and related species in the Caribbean and adjacent waters. Mar. Fish. Rev. 36(9):49-61.

A report on trap fishing explorations that contains information on factors affecting fish trap catch rates such as pot size, mesh size, baiting, and soak period.

Key words: fishing methods, pot design.

MFR Paper 1311. From Marine Fisheries Review, Vol. 40, No. 5-6, May-June 1978. Copies of this paper, in limited numbers, are available from D822, User Services Branch, Environmental Science Information Center, NOAA, Rockville, MD 20852. Copies of Marine Fisheries Review are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402 for \$1.10 each.

First Year of 200-Mile Limit Termed Success

The first year of America's 200-mile fishing zone, which went into effect 1 March 1977, has been pronounced successful by Secretary of Commerce Juanita M. Kreps. Overall, the domestic catch equaled the 1976 level while foreign fishing declined dramatically, giving depleted stocks an opportunity to begin rebuilding, added Richard A. Frank, NOAA Administrator. A modest increase in the U.S. catch, consistent with conservation and management requirements, is expected during 1978.

Early signs also indicate a new vigor in the U.S. fishing industry, the Commerce Department official said. He pointed out that although not enough time has passed for major impact to be felt, orders for new fishing vessels have increased drastically, and new interest is seen in investment in fishing gear and processing plant and equipment.

"The Fishery Conservation and Management Act of 1976 is beginning to work," Frank said. "It effectively reserves the allowable catch off our coasts to U.S. fishermen, permitting foreign vessels to catch only amounts in excess of the U.S. catch. This ensures that vital resources are conserved and that depleted stocks can be rebuilt to be available in the future.

"Development of effective management plans is a complex and lengthy process. The Regional Fishery Councils and NOAA are both working hard to establish an effective system to collect adequate biological, economic, and social data, analyze it, and produce rational management plans and regulations."

The 1977 foreign catch, 1.7 million metric tons (t), was about one million metric tons less than the 1976 foreign

catch and approximately half that of the peak year, 1974. The actual catch was about 400,000 t less than the foreign fishing quota for the year, Frank said. The foreign quotas were set under Preliminary Management Plans adopted by the Secretary of Commerce pursuant to the Act.

The U.S. catch for 1976 and 1977 was about 2.5 million t for each year. U.S. landings of species actually regulated under the Act showed encouraging signs. In the Atlantic, cod and haddock catches, long in decline, increased. Landings of yellowtail flounder, also long declining, stabilized at the previous year's figure. The cod catch in that zone, 31,000 t, represented an increase of 27 percent over 1976; haddock at nearly 10,000 t, doubled; yellowtail flounder remained at 17,000 t.

The U.S. catch of Pacific species under actual regulations saw increases: up to about 45,000 t for 1977 (compared with 17,000 t in 1976) for jack mackerel; up to about 45,000 t in 1977 (compared with 37,000 t in 1976) for snow (tanner) crab. U.S. cod and pollock fisheries in Alaska are showing small increases.

The monthly average of foreign fishing vessels off U.S. shores also de-

Leitzell Is Assistant Administrator for Fisheries

Terry L. Leitzell has been named Assistant Administrator for Fisheries by Richard A. Frank, Administrator of the National Oceanic and Atmospheric Administration, a Department of Commerce agency. He will also be Director of the National Marine Fisheries Service.

Since September of 1977, Leitzell has served as special assistant and senior advisor to the NOAA Administrator. Prior to that, as an attorney-advisor in the Department of State, he was the Deputy U.S. Representative to the United Nations Law of the Sea Conference and chief negotiator on the conference committee dealing with marine pollution and marine scientific re-

search. He led delegations to several meetings and conferences on marine environmental protection and law of the



sea and served as legal advisor to several delegations to bilateral and multilateral fisheries negotiations. Leitzell

was responsible for Executive Branch policy development on law of the sea issues and worked directly with numerous public interest groups on resource and environmental protection policy development.

Leitzell served as consular and commercial officer with the U.S. Foreign Service in Bombay, India, from August 1967 through December 1970. He received an A.B. degree from Cornell University in 1964 and a J.D. from the University of Pennsylvania in 1967.

Leitzell is married to the former Lucy Emmerich and lives in Washington, D.C. They have two children, Thomas 8 and Charles 4.

clined to about one-third less than that of 1976. Preliminary figures show that fewer than 780 foreign fishing vessels operated within the zone during 1977.

The Act, which established the 200 mile fishery zone, also established regional Fishery Management Councils. These Councils develop fishery management plans for the stocks of fish off our coast, subject to the approval of the Department of Commerce. The plans establish quotas for foreign and U.S. fishing.

Secretary Kreps said that the Councils are a new and interesting experiment in Government, preparing Fishery Management Plans to cover specific fisheries with backing by the Federal Government to enforce these plans. She noted that since their formation, the Councils have moved vigorously to prepare these plans so that NOAA can regulate U.S. and foreign fishing in the conservation zone.

So far three Fishery Management Plans have been prepared and approved by the Secretary of Commerce. The first, prepared by the New England Regional Council, covers cod, haddock and yellowtail flounder in the waters of the north Atlantic. Another prepared by the Pacific Regional Council, covers salmon off the northwest coast, and the third, prepared by the Middle Atlantic Regional Council, covers surf clams and quahogs.

An additional plan covering groundfish (flounder, sole, and rockfish) in the Gulf of Alaska, which was prepared by the North Pacific Regional Council was about to be published.

Until Fishery Management Plans have been completed and approved, preliminary Fishery Management Plans adopted by the Secretary of Commerce regulate foreign—but not U.S.—fishing in the conservation zone.

Enforcement of the regulations is carried out jointly by agents of NOAA's National Marine Fisheries Service and the U.S. Coast Guard. Only through the close cooperation of the Coast Guard have we been able to carry out our enforcement duties effectively, Secretary Kreps said.

During 1977 a total of 997 foreign

and 546 U.S. fishing vessels were boarded. The Coast Guard and NMFS agents issued 459 citations and violations against foreign vessels and 352 against U.S. vessels during this period.

Foreign Fish Vessels Hit Two-year Low off United States Coasts

The number of foreign fishing and fishing support vessels sighted within the U.S. 200-mile conservation zone dropped to a two-year low of 158 vessels in January, according to the National Oceanic and Atmospheric Administration's National Marine Fisheries Service. The 206 February foreign fishing vessel sightings were slightly higher but remained well below the 314 seen in February 1977. The January sightings were 30 fewer than the 188 identified in December, and 161 fewer than the 319 sighted in January of 1977, according to preliminary figures released by the Commerce Department agency.

The foreign vessels, from six nations, sighted in January were off the coasts of New England and the mid-Atlantic States and Alaska. The largest number, 77, was from Japan, which had 66 vessels fishing for groundfish and pollock off Alaska, and 11 fishing for squid off New England and mid-Atlantic. The Soviet Union had 38 vessels fishing for groundfish in Alaskan waters.

The ships sighted in February were from seven foreign nations. The largest number, 119, was from Japan which had 114 vessels fishing for groundfish and pollock off Alaska and 5 fishing for squid off New England and the Mid-Atlantic coasts. The Soviet Union had 44 vessels fishing for groundfish in Alaskan waters.

The summary of foreign fishing vessels operating off U.S. coasts during January 1977 and 1978 and February 1977 and 1978 follows.

Foreign vessels sighted off the coasts in 1976 were as follows: January—420, February—510, March—435,

April—560, May—924, June—970, July—842, August—543, September—514, October—452, November—258, December—240. In 1977: January—319, February—314, March—180, April—235, May—374, June—767, July—786, August—492, September—437, October—378, November—256, and December—188. In 1978: January—158, February—206.

The January and February sightings were made by representatives of the National Marine Fisheries Service and by personnel of the U.S. Coast Guard.

Foreign fishing vessels operating off U.S. coasts during January and February 1977 and 1978.

Area	Nation	No. of vessels		No. of vessels	
		Jan. 1978	Jan. 1977	Feb. 1978	Feb. 1977
New England and middle Atlantic	Bulgaria	0	4	0	3
	Canada	0	5	0	0
	Cuba	0	4	0	4
	East Germany	0	4	0	6
	Ireland	0	1	0	1
	Italy	12	16	9	10
	Japan	11	11	5	15
	Mexico	1	0	1	0
	Nigeria	0	1	0	1
	Poland	0	16	0	16
	Romania	0	1	0	0
	South Korea	0	1	0	2
South-east coast West coast	Soviet Union	13	65	13	54
	Spain	15	12	15	21
	Total	52	141	43	133
	Japan			0	5
	South Korea	0	10	0	11
	Panama	0	6	0	7
	Taiwan	0	5	0	7
	Total	0	21	0	25
	Alaska	66	63	114	57
	South Korea	2	0	4	0
	Soviet Union	38	93	44	94
	Taiwan	0	1	1	0
	Total	106	157	163	151
Grand total		158	319	206	314

NMFS Hawaii Cruise Nets Dogfish, Spiny Lobsters

The NOAA ship *Townsend Cromwell* returned to Kewalo Basin, Hawaii, on 9 March from a fishery research cruise to the northwestern Hawaiian Islands. The cruise was part of a continuing series to assess the fishery potential

of the area, said Tamio Otsu, Acting Director of the Southwest Fisheries Center's Honolulu Laboratory, National Marine Fisheries Service.

The *Cromwell* spent 40 days investigating the fishery resources and monitoring environmental conditions in the area extending from Nihoa Island to Midway Island and the Hancock Seamount, said Thomas Hida, Chief Scientist on the cruise. Research activities on the *Cromwell* included trapping experiments for spiny lobsters and bottom fishes and handline fishing for bottom fishes.

One of the highlights of the cruise was the capture of 79 dogfish, *Squalus fernandinus*, a species of shark, in four fish traps set in 150 fathoms (900 feet) of water on the Hancock Seamount. Although dogfish are not presently of commercial value in Hawaii, they are used widely in the fish and chips trade in England, noted Hida.

Also, in cooperation with scientists from the University of Hawaii's Sea Grant Program and the Hawaii Institute of Marine Biology, exploratory dredging for precious corals and shark fish to investigate shark predation on turtles were conducted. Shark fishing at five stations in inshore waters produced only a few sharks and inconclusive results on shark predation on turtles.

The *Cromwell* also transported husband and wife scientific team Brian and Patti Johnson to Laysan Island, where they are conducting a 6-month study of the behavior of monk seals under contract with the Marine Mammal Division, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, Seattle, Wash. Craig Harris of the U.S. Fish and Wildlife Service returned from Laysan to Honolulu on the *Cromwell* with nine live Laysan finches for study.

The scientific field party in addition to Hida included Research Assistants Glenn Higashi, Robert Humphreys, Martina Queeneth, and Darryl Tagami. The Commanding Officer of the *Cromwell* is Commander Edward Gelb of the NOAA Corps.

NMFS Names Jorge Picon Employee of the Year

Jorge E. Picon, Special Agent (Fisheries), in the Southeast Regional Law Enforcement Division, St. Petersburg, Fla., has been chosen the 1976 Outstanding NMFS Employee of the Year. Picon serves as Assistant Special Agent-In-Charge, Field Operations Branch, in the regional office.

Picon is responsible for all field operations conducted by regional Special Agents and for the training and orientation of new enforcement agents. He has also systematized the intelligence and analysis functions of the regional enforcement staff to meet the needs of local and national managers.

Since his appointment in August 1972 as an Enforcement Clerk, Picon obtained a B.A. degree in Criminal Justice from the University of South Florida. According to the NMFS, his Hispanic background has made him uniquely qualified among enforcement agents to undertake many challenging assignments.

These assignments have included extensive Coast Guard sea patrols in the 1973-75 period of extreme tension between Bahamian and Cuban American fishermen on the Bahamas spiny lobster fishing grounds where he was credited with preventing many potentially dangerous confrontations; support of nonfisheries Coast Guard enforcement efforts such as his assistance in the seizure of a vessel on the high seas for a violation of U.S. narcotics laws; and extensive in-depth undercover investigations with respect to endangered species products and marine mammals.

Through cooperation with other Federal agencies, Picon developed the means for locating the positions of foreign fishing vessels in the U.S. waters in the Gulf of Mexico without resorting to costly sea and air patrols. Using his fluency in Spanish, he established intelligence collection and analysis systems for critical regional enforcement programs. In addition, he

established standard procedures for routine reports within the regional office and to NMFS Headquarters.

NOAA Grant Eyes New Aquaculture Technology

Sea Grant scientists at the Oceanic Institute in Hawaii will experiment with rearing fish in captivity in specially built cages in the open ocean under a \$70,000 grant from the National Oceanic and Atmospheric Administration, according to Richard A. Frank, NOAA Administrator. The Federal funds to support this innovative step in aquaculture research will be matched by \$35,000 in non-Federal money.

In the past, the scientists say, most saltwater aquaculture research has been carried out in relatively well-protected coastal waters not subject to intense waves, winds, and currents. However, they explain, if significant increases are to be made in the contribution by saltwater aquaculture to the world food supply, engineers and scientists must learn how to utilize regions of the seas which are exposed to the more intense sea conditions.

In their experimentation, the scientists at the Oceanic Institute will study both floating (surface-following) and stationary (bottom-located) cages, each type equipped with anchors, screens, feeders, floats, and a means of harvesting the cultured fish.

ERRATUM

The article "Krill work reported by Germany and Chile" (Mar. Fish. Rev. 39(10):33) contains contradictory statements referring to the peeling of krill by mechanical means. Item 3) of the article correctly states: "Good results were achieved using mechanized methods of peeling the krill tails, both on board and ashore."

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